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# Engineering and Contracting

H. P. Gillette, *President and Editor*

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## ANNOUNCEMENT OF THE ROAD AND STREET MONTHLY ISSUE OF "ENGINEERING AND CONTRACTING."

Every week for ten and one-half years "Engineering and Contracting" has published articles on roads and streets. With this issue begins the new plan of grouping all the articles on highways in the issue published on the first Wednesday of each month, which will be known as the Road and Street Monthly.

Subscribers desiring only articles on this subject will be able to secure this monthly service for $1 a year. Those who wish the weekly contract news service together with the other three monthly issues of articles—as announced on the front cover—will be entered as subscribers at $3 a year.

The number of engineers and contractors engaged in road and street work is increasing rapidly and will long continue to increase. The autotruck and automobile are destined to make freight and passenger transportation on paved roadways more economic and more popular every year for years to come. We have scarcely begun to build roads in America. Nor have we made more than a good start in paving village and city streets properly. For these reasons we look forward to a road building era that will rival and ultimately surpass the great railroad building era of a generation ago.

Through its monthly articles and its weekly contract news, "Egineering and Contracting" will give to highway engineers and contractors a service superior, we hope, to that securable in any other way.

## THE ROAD PLANK IN THE DEMOCRATIC PLATFORM.

One of the shortest in words, but long in significance, is the road plank of the Democratic party, which reads:

> The happiness, comfort and prosperity of rural life and the development of the city are alike conserved by the construction of public highways. We, therefore, favor national aid in the construction of post roads and roads for military purposes.

So far has sentiment favorable to federal aid in road building progressed that it may be assumed as certain that the old idea that "roads are purely local institutions" will not long survive. First the counties had to assist the "road districts," then the states had to assist the counties, and now the federal government is about to assist the states. This will be done whether Wilson or Hughes is elected.

## A DANGER IN USING BATCHOMETERS.

One ventures on dangerous ground when he undertakes comparison of mixer efficiencies. It is a safe conclusion, however, that there is a substantial difference in the mixing efficiency of the best and of the poorest mixers. Every practical concrete road builder who has observed the work of many different mixers knows that some will turn out a batch of concrete satisfying the expert eye in less time than will others. To the contractor time of batch in the mixer is a very important item. To him the mixing of even × + 5 batches per hour instead of × batches per hour means greater profit. If the quality of each batch of concrete is standard there is no good reason why the contractor should not obtain this extra profit due to greater mixer speed. We assume that no road engineer will deny the justice of this statement.

It is becoming the practice to apply batchometers to mixers used in building concrete roads. It is a practice with which no one quarrels, not even, we believe, the mixer manufacturers. It is, however, a practice which invites loss of efficiency in concrete road work unless regulated with judgment. To illustrate the contention: The editors know of a piece of concrete road work on which several mixers of varying sizes and types were installed by different contractors. By visual inspection it was determined that any of these mixers by retaining the batch 120 seconds would produce a satisfactory concrete. Instructions were issued that batchometers should record two minutes' time in mixer of each batch. Vigorous protest by some of the contractors secured a retest of their mixers and it was found that the best produced as good concrete in 40 seconds as the poorest produced in 120 seconds. A readjustment was made by which each batchometer was rated according to the efficiency of the mixer to which it was applied. This was a perfectly logical action, and it is always the only logical action.

We often hear reference to the "average commercial mixer." There is no such thing. Each size and type of mixer is a different machine. Perhaps the difference may not be great between a selected two mixers, but it is substantial when we compare extremes in size and type. To rate batchometers to an arbitrary time of batch in mixed based on records of "average commercial mixers" is handicapping the mixer superior to the average and giving an unjust advantage to the mixer inferior to the average.

## SPECIFICATIONS FOR ROAD CONCRETE AGGREGATES.

The general principle of control of quality of engineering materials is satisfaction by the finished product of test requirements. Quality of concrete, however, is controlled by specifying the properties that the materials of which concrete is made shall have. Rarely is strength, density, abrasion resistance, or any other physical or other property of the finished product, specified. How and why this variation from common procedure has come about in the instance of concrete we need not inquire. It exists without a doubt and its existence is not a good thing for concrete engineering because it does not permit the use of a wide choice of materials, particularly aggregates, of which good concrete can be made.

The possibilities of concrete for road construction lie largely in the facilities which it offers for the use of local materials for the great bulk of the concrete volume. The very moment it is necessary to send away for aggregates concrete as a permanent road material begins to lose any economic superiority it may possess. It follows that to increase the use of concrete in road construction the widest possible opportunity compatible with good construction must be offered to the use of local aggregates. This opportunity the conventional concrete specifications does not give. Let us consider the reason.

The standard concrete road specification first establishes an arbitrary proportion, say a 1:2:3 mixture. Next it stipulates precisely the character, properties and quality of the cement, the sand and the coarse aggregate. With these proportions using cement and aggregates meeting the stipulations of the specification and employing proper mixing procedure a good concrete is reasonably certain. This is an acknowledged merit of the standard road specification. But granting it this merit, the fact remains that other proportions and other characters of materials not comprehended in the specification will also produce a good concrete for pavement. Since those other proportions and characters of materials make a good road concrete no specification is serving its purpose best which puts them outside the pale of approved practice. Specifications serve a most important purpose when they ensure a good material. Let it not be forgotten, however, that specifications serve the industry best when they comprehend all means capable of producing a good material.

How can such a specification for road concrete be written? We doubt whether it can be written following precedent. It can be written if engineers will come to consider that the object sought is quality of concrete and not character, properties and quality of aggregates. No doubt we should need first some amassing of data and some study to develop practicable test measures of quality, but these are not insurmountable obstacles if vigorously attacked. A concrete road specification that establishes as standard of measure quality of concrete has some chance of being universally obeyed, but there is slight chance of securing obedience to a specification that makes quality of aggregates the standard of measure.

## HAS THE "COUNTRY GONE CRAZY ON ROAD CONSTRUCTION"?

Under this title we published an editorial four years ago (Sept. 25, 1912), most of which will bear repeating now, for some daily papers and even the Good Roads Magazine have been opposing the pending road law that Congress is about to pass. It is urged that Federal aid is not needed, that road building has been going on at a satisfactory rate without Federal aid, that the country has gone crazy on automobiles and roads. We leave to others the defense of expenditures for automobiles, and take upon ourselves to show how absurd is the contention that there has been too much road building.

In the editorial above referred to we showed that the per capita investment in country roads was only $30 in America, as contrasted with about $200 per capita invested in steam railways. During a period of five years (1904 to 1909) the railways added to their investment $10 per capita, whereas during the same period only 30 ct. per capital was expended in improving the surface of roads by graveling, macadamizing or other betterment of a so-called permanent type. The then ratio of investments in railways and roads was about 7 to 1, and the ratio of annual additions to that investment was 30 to 1, showing that even in a poor railroad building era our country roads were continuing relatively to fall behind the railroads. We hope soon to present data that will show the relative progress during the years 1909 to 1914. Certainly there has been some relative gain in road expenditures, but equally certain is it that we face a long, long way to the Tipperary of satisfactory road expenditures.

When talking in great totals one is apt to lose a sense of proportion. But by reducing totals to a per capita basis we gain a rational conception of what the totals really mean.

In 1909 there were 190,500 miles of surfaced roads in America, whose total cost was about $507,000,000 Half a billion dollars sounds huge, but it was only $5.60 per capita. More money than that total annually goes up in tobacco smoke and down in alcoholic drink, yet there are objectors to bond issues for road improvement.

## BOULDER AND MASONRY PARAPETS ON ROAD EMBANKMENTS.

Guard rails or parapet walls on road embankments, particularly at curves, are essential to protection against accidents. Wooden guard rails are not only expensive in first cost, but in maintenance. Moreover, they are not things of beauty. Parapet walls of masonry are far preferable from the aesthetic point of view, and frequently can be built at so low a cost as to make their construction advisable.

An effective parapet wall may be made or large, boulder-like pieces of rock blasted from a cut made in grading the roadbed. The cost of hauling and placing the stones is the sole cost of such a wall where a cut yields a sufficient quantity of large stones for the purpose. The larger the boulders the greater the safety secured by such a wall. On a mountain road heavy boulder parapets add greatly to the feeling of security of automobilists, a factor not to be ignored, particularly in the construction of scenic highways.

Where the rock from cuts breaks into small fragments, so that large "boulders" are not available, dry rubble parapet walls can usually be built at relatively low cost. In these days of concrete, engineers are prone to overlook the suitability and economy of dry rubble for such purposes as this. Since embankments usually settle, concrete or mortared masonry parapet walls crack if laid soon after the embankment is finished. This, however, is less objectionable than is the higher unit cost of such masonry. A parapet wall needs to have sufficient mass to resist a heavy impact, but it gains nothing by being watertight.

In riding over a mountain road in California, recently built by the state, the editor was impressed by the necessity of providing greater protection by walls or guard rails. It was a positive relief to ride through a cut after skirting the edge of a high fill on a sharp curve.

Where rock is scarce, may it not be wise to build parapets of earth along the edges of fills? The slopes of earth parapets may be protected from rain wash by a thin slope wall of dry masonry or by thin concrete slabs.

## THE FIELD FOR SMALL POWER MACHINES AS ILLUSTRATED BY THE "IRON MULE."

When the average engineer or contractor begins to plan the use of steam or gasoline power there is an almost irresistible tendency to use relatively large engines. The cost of the fuel is relatively slight, and one engineman can control 50 as easily as 5 hp., so the designer is apt to forget that he is not seeking a low cost per horsepower, but a low cost per unit of construction work.

A mule is often a better engine than a 10 hp. motor, because the mule is self-portable at a fairly rapid gait over bad roads or no roads at all, and yet his 1 hp., or more correctly 1 mp., is economically ample for the purpose.

Not long ago the editor was talking with an engineer who was in charge of erecting a pole line through a rough, timbered country where even mules could not travel. A span of mules had been used previously to "snake" poles around and to raise the poles by the aid of gin pole. The engineer decided to make an "iron mule" to do this sort of work, so he bought a second-hand motorcycle, put its engine on a light frame and geared it to a drum. Three speeds were secured through the gearing. Four men readily carried the outfit, and it proved to be in every way as useful as a span of mules had been. By anchoring it to a stump, or a tree, or a few iron pins driven into the earth, this miniature hoisting engine was capable of "snaking" large poles, erecting an A-frame derrick and hoisting the poles.

This is an example of what we have in mind when we say that small power machines are frequently the most economic. There is a vast amount of construction work of relatively light nature as to each unit but involving a large number of units that are scattered and therefore requiring the frequent shifting of the working force. On such work if machines are to be used economically they must be readily portable, and this involves lightness unless there are good roads. The mule is so effective because he comes in portable units that can be grouped together where much power is required. Why can't we have more "iron mules" of the sort above described?

May it not be that walking machines, rather than rolling machines, are to be preferred for many classes of work where portability is needed? There is already the "walking dredge" which moves its own huge weight over land by a sort of walking motion. Why not produce a "walking iron mule"?

Transportation on wheels unquestionably requires less power than by walking, provided there is a suitable roadway for the wheels, but a suitable roadway is the very thing that is lacking in many cases and to build one may be out of the question. The caterpillar or apron wheel has solved the problem of self-propulsion over fairly smooth and preferably soft surfaces, but there are conditions where it is not applicable, and where a light "walking machine" would be preferable. Who will make a practical, simple "iron mule" that will walk?

## EDITORIAL PARAGRAPHS.

What is the loss of coarse aggregate in concrete road work? Some is lost in shipping, being either spilled or left in the cars, and more is lost in picking up the material on the road. To how much do these losses amount? We believe that it is at least 10 per cent. Who has exact figures?

Last year there were almost 2,500,000 motor cars registered in America, or one for every 44 persons. Iowa led with one for every 16 persons. The number of motor cars in 1915 was almost double the number in 1913. Motor car owners paid more than $18,000,000 in taxes in 1915, most of which went into road improvement.

When the Russians were going the other way across Poland last summer they, according to Major Bond's "The Engineer in War," spitefully dragged behind themselves many ordinary road scarifiers having all their claws extended. Anyone who has seen what one of these dumpy little devices can do to a perfectly good road can appreciate the feelings of the German artillerist charged with keeping a sizeable fieldpiece within a useful distance from the Slav rear guard.

Speaking further of road construction under war conditions Major Bond warns that no plant will be ordinarily attainable and the engineer must make small tools suffice. He naively remarks, however, that "explosives will be available and many be liberally employed."

A plank road has little to commend it, but a road plank is commendable even if little—as little as that in the Democratic party platform.

In Clayton County, Iowa, there are 226 miles of county roads that are maintained by the patrol system. The length of each patrol is 7 to 10 miles. Patrolmen contract with the county to drag the earth roads as ordered. The cost of dragging has averaged 57 ct. per mile per round trip. This low cost suggests the desirability of a more general adoption of the contract system of road dragging.

## HAULING BROKEN STONE FOR ROAD CONSTRUCTION, ROCKFORD, ILL.

Contributed by The Thomas B. Jeffery Company, Kenosha, Wis.

A clear profit of over $2,000 in six months is the record made by a motor truck operated by a contractor in Rockford, Illinois. The concern in question is Hart & Page, who own a limestone quarry in Rockford and are responsible for the building of many miles of the fine roads to be found in the northeastern part of the State of Illinois.

Early in 1915, Mr. Rea Hart, of Hart & Page, began to look seriously into the haulage situation on account of the growing scarcity of good horses and the rapidly increasing cost of operating teams. He soon became convinced that the only economical solution was a motor truck. After witnessing numerous demonstrations, and making exhaustive inquiries among motor truck owners he decided that he needed for his work a truck with power applied to all four wheels. His selection was the Jefferey Quad, a motor truck which drives, brakes and steers on all four wheels. Mr. Hart was certain he needed at least a four or five-ton truck and possibly a six or seven-ton truck, whereas the Jeffery Quad has a rated load-carrying capacity of only two tons. He tried, unsuccessfully, to get the company to guarantee the Quad to haul three tons in its own body and to pull five or six tons additional in trailers. The company refused to accept the order on such a guarantee.

Finally, Mr. Hart purchased a Quad and two trailers. He had the Quad equipped with a Lally hand-operated, all-steel dump body, and the trailers with the conventional bottom-dump bodies, which are very commonly used by contractors all over the country. In order to enable the truck to pull the loaded trailers onto the job over the unmade roads, he instructed the Joslyn Automobile Co., Jeffery dealers at Rockford, to install a subtransmission giving an extra low gear ratio. His judgment proved to be sound, for in the six months from May 18 to Nov. 24, 1915, the Quad with its Bain trailers hauled a total of 7,500 tons of crushed rock, covering a total mileage of 6,000 miles.

Jeffery Quad Road Material Hauling Outfit.

Figuring each ton of rock hauled the same as if hauled by contract with teams and charging the truck with first cost and interest, and all money expended on it, the truck shows a net earning of over $2,000 for the six-month period.

## ROAD CONSTRUCTION OPPORTUNITIES IN WEST VIRGINIA.

The state of West Virginia at the present time offers an excellent field for the road contractor. Few sections of the country offer more highway construction opportunities. Since November, 1911, bond issues for road improvement aggregating $12,388,500 have been authorized in various counties. Of this amount $11,508,500 has been voted during the past two years. Of the $12,388,500 authorized, approximately $2,700,000 has been expended. At the present time the greater part of this fund is unbound by contract as the work is just being contracted for in various sections of the state. The accompanying tabulation (Table 1), furnished by Mr. A. D. Williams, Morgantown, W. Va., chief road engineer, shows the bond issues voted up to June 20, 1916.

The following notes indicate the highway construction activities in several of the counties of West Virginia:

On June 26 the County Court of Preston County received bids on work in Portland and Kingwood Districts aggregating 50 miles of improved road; R. R. Feller, Terra Alta, engineer in charge of Portland District; J. K. Monroe, Kingwood, engineer in charge of Kingwood District.

On June 29 the County Court of Wetzel County received bids on Church District road improvement aggregating 18 miles, improvement to be made of brick, concrete or asphaltic surface; J. Russell Wilson, Mannington, engineer in charge.

TABLE I.—BOND ISSUES IN WEST VIRGINIA FOR ROAD IMPROVEMENT.

| Date of erection. | | County. | District. | Amount of issue. | Date of sale. | Amt. bonds sold for. |
|---|---|---|---|---|---|---|
| Mon. | Year. | | | | | |
| Feb., | 1911 | Wood | Parkersburg | $180,000 | July, 1911 | $180,697 |
| May, | 1911 | Cabell | | 300,000 | 1912-14 | 300,375 |
| Oct., | 1911 | Hancock | Grant | 125,000 | Apr., 1912 | 125,000 |
| Nov., | 1912 | Hancock | Butler | 125,000 | May, 1913 | 125,000 |
| Nov., | 1912 | Marshall | Union | 150,000 | 1913-1916 | 150,000 |
| May, | 1913 | Marion | Fairmont | 400,000 | Sept., 1913 | 400,000 |
| Jun., | 1913 | Marion | Mannington | 300,000 | Sept., 1913 | 300,000 |
| Dec, | 1913 | Mercer | | 500,000 | .......... | 515,795 |
| Dec., | 1913 | Pleasants | Washington | 60,000 | As used | 60,000 |
| Mar., | 1914 | Wood | Williams | 70,000 | Mar., 1914 | 71,147 |
| May, | 1914 | Wood | Clay | 40,000 | Feb., 1915 | 40,333 |
| May, | 1914 | Hancock | Clay | 40,000 | June, 1914 | 40,000 |
| Mar., | 1915 | McDowell | Big Creek | 165,000 | May, 1915 | 165,000 |
| .......... | | McDowell | Sandy River | 293,000 | .......... | ....... |
| May, | 1915 | Cabell | | 600,000 | .......... | ....... |
| May, | 1915 | Kanawha | Poca | 25,000 | .......... | 25,000 |
| May, | 1915 | Kanawha | Union | 50,000 | .......... | 50,000 |
| May, | 1915 | Kanawha | Jefferson | 90,000 | .......... | 90,000 |
| May, | 1915 | Kanawha | Malden | 45,000 | .......... | 45,000 |
| May, | 1915 | Kanawha | Charleston | 80,000 | .......... | 80,000 |
| May, | 1915 | Kanawha | Loudon | 85,000 | .......... | 85,000 |
| May, | 1915 | Mercer | | 350,000 | .......... | 350,000 |
| Aug., | 1915 | Summers | Talcott | 100,000 | .......... | 100,000 |
| Aug., | 1915 | Summers | Greenbrier | 150,000 | .......... | 150,000 |
| Aug., | 1915 | Wyoming | | 550,000 | Dec., 1915 | 550,000 |
| Sep., | 1915 | Monongalia | Morgan | 300,000 | Dec., 1915 | 304,803 |
| Dec., | 1915 | Preston | Portland | 280,000 | Mar., 1916 | 286,200 |
| Jan., | 1916 | Preston | Kingwood | 164,000 | .......... | ....... |
| Jan., | 1916 | Upshur | Buckhannon | 181,000 | .......... | ....... |
| Mar., | 1916 | Doddridge | West Union | 200,000 | Apr., 1916 | 200,200 |
| Jun., | 1915 | Marion | Fairmont | 100,000 | Sept., 1915 | 1000,000 |
| Mar., | 1916 | Hancock | Poe | 50,000 | .......... | ....... |
| Mar., | 1916 | Randolph | Leadsville | 220,000 | May, 1916 | 223,100 |
| Apr., | 1916 | Raleigh | Town | 300,000 | .......... | ....... |
| Apr., | 1916 | Raleigh | Trap Hill | 175,000 | .......... | ....... |
| Apr., | 1916 | Raleigh | Shady Springs | 135,000 | .......... | ....... |
| Apr., | 1916 | Raleigh | Slab Fork | 210,000 | .......... | ....... |
| Apr., | 1916 | Barbour | Barker | 130,000 | .......... | ....... |
| Apr., | 1916 | Roane | Spencer | 240,000 | .......... | ....... |
| Apr., | 1916 | Greenbrier | White Sulphur | 90,000 | July, 1916 | ....... |
| Apr., | 1916 | Wetzel | Church | 240,000 | .......... | ....... |
| Apr., | 1916 | Greenbrier | Lewisburg | 153,500 | July, 1916 | ....... |
| Apr., | 1916 | Logan | Logan | 200,000 | .......... | ....... |
| Apr. | 1916 | Marion | Lincoln | 650,000 | .......... | ....... |
| May, | 1916 | Wood | Tygart | 70,000 | .......... | ....... |
| May, | 1916 | Doddridge | Grant | 175,000 | .......... | ....... |
| May, | 1916 | Hancock | Clay | 40,000 | .......... | ....... |
| May, | 1916 | Hancock | Grant | 125,000 | .......... | ....... |
| May, | 1916 | Ritchie | Clay | 240,000 | .......... | ....... |
| May, | 1916 | Fayette | Fayetteville | 600,000 | .......... | ....... |
| May, | 1916 | Fayette | Falls | 175,000 | .......... | ....... |
| May, | 1916 | Fayette | Nuttal | 100,000 | .......... | ....... |
| May, | 1916 | Roane | Walton | 208,000 | .......... | ....... |
| July, | 1913 | Wetzel | Grant | 150,000 | .......... | ....... |
| May, | 1916 | Fayette | Kanawha | 350,000 | .......... | ....... |
| .......... | | Kanawha | Big Sandy | 170,000 | .......... | ....... |
| Jun., | 1916 | Fayette | Sewell M't'n | 175,000 | .......... | ....... |
| .......... | | Harrison | Clay | 300,000 | .......... | ....... |
| .......... | | Brooke | | 800,000 | .......... | ....... |

On July 1st the County Court of Randolph County received bids on 22 miles of road construction, surface to be concrete, asphaltic concrete, brick, and macadam; P. B. Broomfield, Elkins, West Virginia, engineer in charge.

On June 17 the County Court of Ritchie County sold $240,000 Clay District bonds to Otis & Company at a premium of $1,805 and will advertise for bids on 18 miles of construction as soon as plans and specifications can be prepared; W. D. Britt, Clarksburg, in charge.

The County Court of Wood County, Parkersburg, W. Va., has recently sold $70,000 Tigart District bonds at a premium of $100 to the local banks in Parkersburg. Work will be done by force account under direction of Burdette Woodyard, county engineer.

The County Court of Roane County, Spencer, W. Va., sold $240,000 Spencer District bonds to Harris Forbes & Co. at a premium of $650 and the blank bonds.

On July 8 the County Court of Greenbrier County, Lewisburg, W. Va., will receive bids on $153,500 Lewisburg District bonds and $90,000 White Sulphur District bonds.

On July 24 the County Court of Fayette County, Fayetteville, W. Va., will receive bids on District bonds: $600,000, Fayetteville; $175,000, Falls; $100,000, Nuttall; $175,000, Sewell Mountain.

The County Court of Raleigh County, Beckley, W. Va., has recently sold $835,000 Shady Spring, Trap Hill, Slab Fork and Town District bonds at a premium of $10,742 and is now preparing to carry out the necessary arrangements to start the construction.

The County Court of Summers County has awarded the contract for 8 miles of asphaltic concrete to the Central Engineering Co. at Charleston, W. Va. F. K. Rader, Lewisburg; Phillip J. Konrad, Kanawha Falls, engineers in charge.

The County Court of Hancock County has recently sold $125,000 Grant District bonds, $50,000 Poe District bonds, $40,000 Clay District bonds, and are now having surveys made preparatory to advertising for bids; C. E. Grafton, New Cumberland, engineer in charge.

Logan District, Logan County, has voted $200,000 5 per cent serial bonds; F. M. Wilson, county engineer, Logan, W. Va., is making surveys and preparing plans and specifications.

The County Court of Doddridge County has decided to do the work in Grant District under the $175,000 bond issue by force account and has employed Arthur Lucas, civil engineer of Morgantown, W. Va., to take charge of the work.

## METHODS AND COST OF TREATING OLD MACADAM STREETS IN MILWAUKEE, WIS., WITH ASPHALTIC OIL.

Contributed by Stanley E. Bates, Assoc. M. Am. Soc. C. E., Chicago, Ill.

Like scores of other American cities, Milwaukee, during the past few years has been confronted with the serious problem of caring for a large mileage of old waterbound macadam streets bearing a traffic too heavy for this type of construction.

With 200 miles of such streets, immediate replacement with a higher type of pavement is impossible; on the other hand, maintaining them as waterbound pavements is well-nigh impossible—to say nothing of the cost. Maintenance with liquid asphaltic oil has been found the answer to the problem in Milwaukee. The method of application is as follows:

Oiling is done only when the streets are perfectly dry. The surface is first swept clean by means of steel and fibre brooms, removing all loose dirt and dust. This includes, likewise, loose stones in the macadam.

Immediately, upon this clean, dry and somewhat rough surface, the liquid asphalt is applied, sometimes by hand, but more often with a gravity distributor. Milwaukee's distributor is an old converted sprinkling cart, fitted with a transverse perforated pipe and proper connections. The liquid is applied cold, the amount put on averaging about ⅝ gal. per square yard.

As soon as the asphalt is applied it is broomed with heavy fibre brooms, not only to insure a uniform and even distribution, but to thoroughly coat all of the particles on the macadam surface and insure good adhesion. In some cases, horse-drawn rotary brooms are used for this work, but only when the macadam has an even surface without holes or depressions.

Following the brooming, clean stone screenings, sand or granulated slag is spread over the surface. This is done either by hand or machine, the use of a sand spreader manufactured by the Kindling Machinery Co., Milwaukee, Wis., and shown in operation in Fig. 1, being much more economical than hand spreading.

The Kindling spreader consists of an ordinary wagon with a hopper bottom and a steel chute discharging onto a rotating metal disc fitted with radial blades. A chain and sprocket wheels, together with bevel gears connecting the rear wheels of the wagon to the shaft, makes the disc rotate at about 25 times the speed of the wheels. This is sufficient to throw the material out, by centrifugal force, over the entire width of an ordinary street, spreading it as evenly as by hand. A maximum of 50,000 sq. yd. per hour can be covered, but usually the rate is considerably less in this kind of work. The rate of flow of the sand or other material is controlled by a lever at the driver's seat. Only one man is required to operate the spreader.

The size of screenings generally ranges from ½ in.

down; sand and granulated slag ranges from ¼ in. down. The average rate of spreading is such that 1 cu. yd. covers about 275 sq. yd. of surface.

The street is closed to traffic until 48 hours have elapsed after spreading the sand. By that time the liquid asphalt has solidified so that it is not picked up by the wheels of wagons or automobiles. Then, as traffic goes over the surface, the sand or screenings are gradually pressed down into the matrix until a smooth, hard surface is obtained. Fig. 2 shows a close view of the surface about 30 days after treatment. In another 60 days the pebbles were pressed down so as to be scarcely visible.

For deep holes in the old macadam, special treatment is required. When liquid asphalt was first tried out in Milwaukee, such holes were filled with crushed stone before the asphalt was applied. Experience proved that this was not very satisfactory, as there was no bond between the macadam and the new stone and the latter became dislodged easily. On all recent work, therefore, the holes are left unfilled until after the asphalt has been applied. This results in the interior of the depressions being coated with the adhesive material, after which they are filled up level with the surrounding surface with crushed stone as before. But in this case, the asphalt at the bottom furnishes a bond to hold the stone in place and then an additional amount of liquid is poured over the patch, cementing the stone firmly together. Such patches generally cannot be detected on the finished surface.

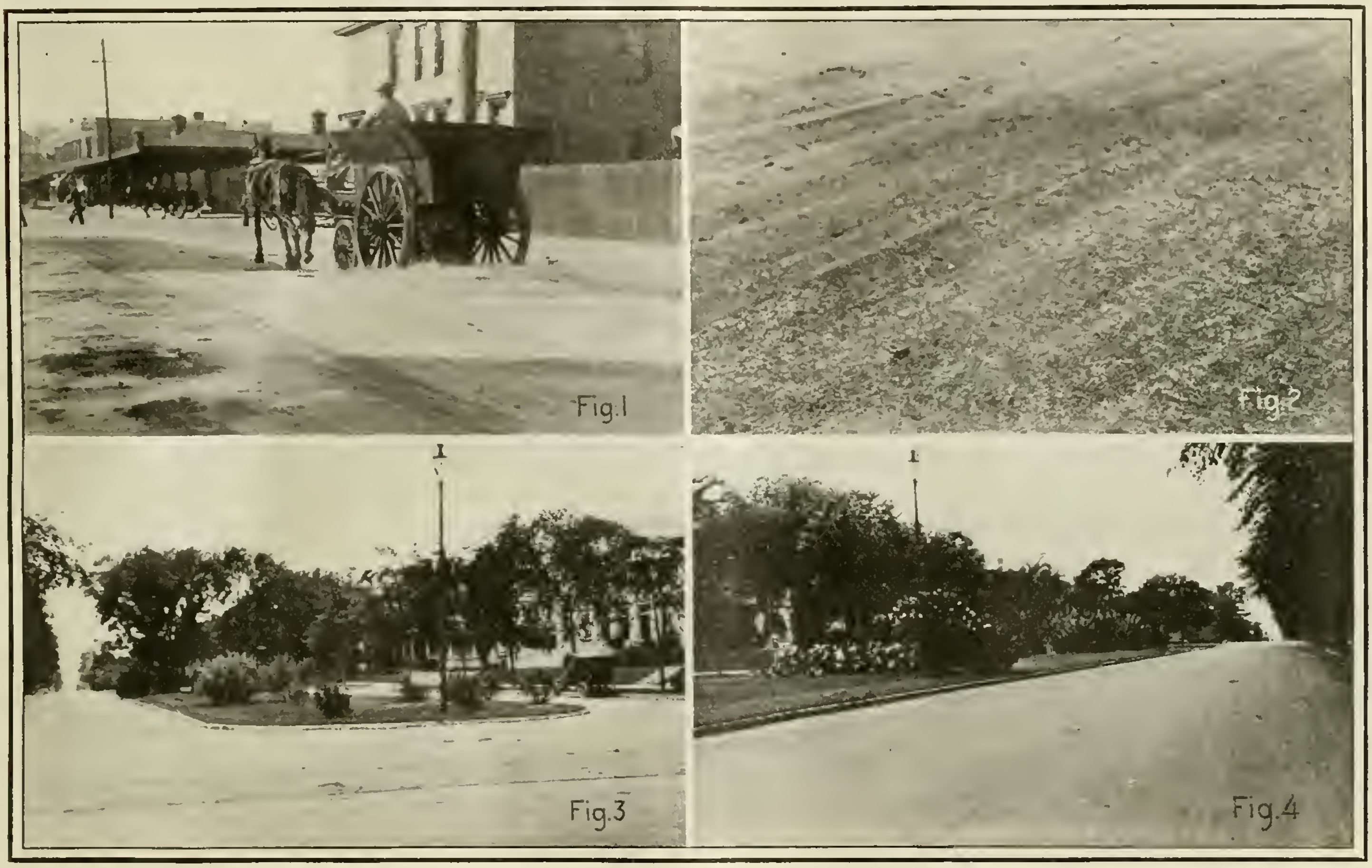


Fig. 1—Kindling Sand Spreader in Operation. Fig. 2—Close View of Treated Macadam Near Gutter—Asphalt Application One Month Old. Fig. 3—Looking West on Highland Boulevard From Washington Avenue—Boulevard Has Old Macadam Pavement Treated With Asphalt. Fig 4—Highland Boulevard After One Application of Liquid Asphalt.

The above described treatment is applied to macadam streets every year or sometimes every two years, depending upon traffic and the original condition of the street. By this means a substantial surface is built up, closely resembling sheet asphalt; in fact, even after the first application, when the liquid asphalt has solidified and traffic has ironed down the sand or screenings into it, there is difficulty in distinguishing the dividing line between sheet asphalt and the treated macadam, where the two adjoin.

In Fig 3 the transverse street in the immediate foreground is of sheet asphalt, while the boulevard is of macadam. Casual observation on the ground would detect little difference.

Three kinds of asphalt were used in Milwaukee during 1915, viz.: Trinidad Liquid of the Barber Asphalt Paving Co., Mexican of the Standard Oil Co. of New Jersey, and Stanolind of the Standard Oil Co. of Indiana. Prices ranged from 3.17 ct. per gallon to 6.9 ct.

Owing to the large number of widely variable factors entering into the cost of such treatment, representative data are difficult to obtain. The condition of the old pavement, the price of oil and sand, and the use of hand methods versus machinery for application, are the items subject to greatest variation. However, the following table is given which, as near as possible, represents a fair average case; if anything, it is conservative, as hand methods were employed throughout, though less materials were used than those given in the earlier part of this article. All work was done by force account. The table was compiled from figures kept by the Bureau of Municipal Research of Milwaukee.

TABLE 1.—ITEMIZED COST OF OILING TERRACE AVE., BETWEEN LAFAYETTE PL. AND WYOMING PL., FOUR BLOCKS, 5,306.20 SQ. YDS., 2,728.9 FT. FRONTAGE. TRINIDAD LIQUID ASPHALT USED.

| Labor and teams. | Hours. | Rate per hour Cts. | Cost Total. | Cost Per 1,000 sq. yds. | Cost Per front ft. |
|---|---|---|---|---|---|
| Hand Sweeping— | | | | | |
| Labor | 22 | 25 | $5.50 | $1.03 | $0.00200 |
| Teams | 3 | 62½ | 1.875 | .35 | .00069 |
| Hauling and Hand Spreading of Oil— | | | | | |
| Labor | 30 | 25 | 7.50 | 1.41 | .00275 |
| Teams | 4 | 62½ | 2.50 | .47 | .00091 |
| Spreading Slag (by hand)— | | | | | |
| Labor | 41 | 25 | 10.25 | 1.93 | .00370 |
| Teams | 10 | 62½ | 6.25 | 1.18 | .00229 |
| Totals— | | | | | |
| Labor | 93 | 25 | 23.25 | 4.38 | .00845 |
| Teams | 17 | 62½ | 10.625 | 2.00 | .00389 |
| Total | | | $33.875 | $6.38 | $0.01234 |
| Materials. | Quantity. | Unit cost. | Cost Total | Cost Per 1,000 sq. yds | Cost Per front ft. |
| Oil, gal | 1,100 | $0.069 | $75.90 | $14.30 | $0.02782 |
| Slag, cu. yd | 19 | 1.00 | 27.40 | 5.16 | .01004 |
| Sand, cu. yd | 6 | 1.40 | | | |
| Total | | | $103.30 | $19.46 | $0.03786 |
| Grand total, labor and materials | | | $137.175 | $25.84 | $0.05020 |

The following, Table II, shows the amount of materials used on this street:

TABLE II.—QUANTITIES OF MATERIALS USED ON TERRACE AVE. BETWEEN LAFAYETTE PL. AND WYOMING PL.

| Material and unit. | Quantity. Total. | Quantity. Per 1,000 sq. yds. | Quantity. Per front foot. | Sq. yd. covered by unit quantity. |
|---|---|---|---|---|
| Oil, gal. | 1,100 | 207 | .403 | 4.8 |
| Slag and sand, cu. yd. | 25 | 4.7 | .009 | 212 |

Charles O. Davis, Superintendent of Street Sanitation of Milwaukee, has direct charge of all street maintenance by oiling.

## MOTOR TRUCKS FOR EARTH EXCAVATION FOR THE PUBLIC SERVICE TERMINAL, NEWARK, N. J.

Contributed by the Pierce-Arrow Motor Car Co., Buffalo, N. Y.

Among the most striking records of motor truck service in contracting are those covering a million-dollar excavating contract by Holbrook, Cabot & Rollins, New York, N. Y., for the Public Service Terminal at Park Place, Newark, N. J. This contract called for the excavation of over 120,000 cu. yd. of earth to be removed from a plot 900 ft. long, with an average width of 140 ft. and a depth of 25 ft. below curb. In addition there were 136 caissons, averaging 8 ft. in diameter, to be sunk to a depth of at least 58 ft. in order to reach rock.

An Earth Hauling Outfit of Pierce-Arrow Motor Trucks.

In hauling the excavated material from ten to twelve Pierce-Arrow trucks were employed. The trucks were operated 18 hours a day, working two 9-hour shifts of men, one going on at 5 a. am. and the other quitting at midnight. With ten trucks in service the average working per day was 9¾ trucks. The only truck troubles were a few broken springs, due to the rough road over which the hauling was done. With the ten trucks working 18 hours per day, 28 trips per truck, of 5½ miles, were made. Each truck carried a load of 4 cu. yd. or a total of 112 cu. yd. per day. The trucks were loaded by steam shovel, and the average time of loading was 3 minutes. A concise statement of the operations is contained in the following report, submitted Dec. 2, 1914, after the work was well under way:

Ten 4-yard, 5-ton Pierce-Arrow trucks in 15 weeks carried 53,000 cu. yd. earth excavation 7 miles to make a four-foot fill 18 ft wide and 2 miles long. This sand, loam and gravel was loaded by a Bucyrus 18 B, 25-ton revolving shovel from the ⅞-yd. dipper directly into the trucks, which took it up a 400-foot 5 per cent grade planked ramp, then over cobblestone and other poor pavement in streets with car tracks and over one drawbridge to the above mentioned fill, which was parallel to, but only connected at intervals with, the turnpike road. The time of loading varied from one to five minutes and up. Unloading, about the same time. The following are the figures:

| | |
|---|---|
| Number of trucks on the job | 10 |
| Number of trucks actually at work, average about | 9½ |
| Number of loads | 13,928 |
| Average loads, cu. yd. | 3.8 |
| Average weight of load at 98 lb. per cu. ft., tons | 4.9 |
| Total mileage for 9½ trucks | 98,888 |
| Average mileage 1 truck | 10,400 |
| Number of days worked (Sunday not included) | 90 |
| Number of days two shifts worked | 74 |
| Total shifts worked in 90 days | 165 |
| Average miles per 9½ hour shift for 9½ trucks | 600 |
| Average mile per truck per 9½ hour shift | 63 |

The books show that the overhead expense was $8 a day, which included interest, insurance, garage service, and the salaries of the two drivers. The operating expense was shown to be 18 ct. per mile, which included tires, gasoline, oil, repairs and depreciation. Figuring on the basis of each truck making 154 miles per 18-hour day, which was the average, the total cost per truck per day was $35.72, and this reduced to the cost of yardage removed, figured out 32 ct. per yard.

In estimating what the cost of doing this work with horse teams would have been, it was figured that there was a saving of approximately 60 per cent in favor of the motor trucks. The net saving on this basis would amount to $550 a day. It is somewhat idle, however, to speculate along these lines, for it is a plain statement of fact that horse teams simply could not have done the work at any cost within the contract time. Mr. T. B. Bryson, Vice-President of the Holbrook, Cabot & Rollins Corporation, writes us on this point: "Replying to your letter of Dec. 3, regarding Pierce-Arrow trucks on work at Newark, would say that it would be impossible to have done the work in question with horse trucks on account of the length of the haul and also the fact that we could not have gotten the teams to the shovel and away with dispatch enough to have loaded the yardage which we were loading per day."

**Safety in Highway Construction.**—Several serious accidents have happened on high fills which could have been avoided if the instructions of the highway commission to place guard rails on all fills of over five feet in height were compiled with, says the Minnesota Highway Journal. This is a rule on state roads, and should be applied to all roads. One county had trouble even with guard rails, several machines having gone through the fence on a bad turn, until the engineer put on some woven wire. A machine occasionally runs into the fence but does not go over the edge of embankment as the wire holds it. When roads are surfaced the shoulders should be built up of firm material to allow for turning out, especially in sandy soil. A clear sight distance of not less than 250 ft. should be provided on all roads, and would prevent many accidents, particularly those accidents occurring by the lights of automobiles suddenly coming upon a team at night.

## COMPARATIVE COST OF VARIOUS TYPES OF PAVEMENT.

Interesting figures on the comparative costs of various types of pavement were given by Mr. Eugene W. Stern, Chief Engineer of Highways, Borough of Manhattan, New York City, in a paper presented at the Second National Conference on Concrete Road Building. The following data are quoted from Mr. Stern's paper:

While there is no uncertainty about the first cost, there is some difficulty, however, in properly arriving at the maintenance cost. The most approved types of highways have been in common use for a short time only and the motor traffic is very recent; and while we know a good deal as to their durability under present conditions, we must look ahead and try to foretell how long their life will be and what the probable cost of maintenance over this period of years will be.

Let us consider now the following well-known types of roads and pavements:

Concrete.
Bituminous concrete on concrete base.
Sheet asphalt on concrete base.
Brick on concrete base.
Bituminous macadam on gravel or broken stone base.
Asphalt block on concrete base.
Water-bound macadam.
Wood block on concrete base.
Granite block on concrete base.

In order to arrive at a basis for comparison, let us reduce all these various types to a gross annual cost per square yard, which includes interest on first cost, plus amortization, plus annual repairs.

I have taken the country district immediately about New York City as a basis for comparison as to cost and therefore, of course, the figures of first cost given below must be modified to suit local conditions. In some districts, for instance, such as Worcester, Mass., a granite pavement can be laid with cement grouted joints and with concrete base for as low as $3.10 a square yard, with an annual maintenance cost averaged for 15 years of only 6 10 ct. a square yard. There are places in the middle west where a brick pavement can be laid for considerably less.

As regards maintenance costs, I have taken the figures for recent years only, because the farther back one goes, the farther we get away from present conditions.

### CONCRETE PAVEMENT.

Assumptions.—Useful life at 20 years as a wearing surface; after which to be used as foundation for a wearing surface such as bituminous concrete, sheet asphalt, asphalt block, brick, etc.

| | Per sq. yd. |
|---|---|
| Cost of concrete pavement, 6 in. thick | $1.12 |
| Value as a foundation | .80 |
| Cost of wearing surface, 20-year life | $0.32 |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $1.12 at 4¼% | 4.76 |
| Amortization on wearing surface, 32 ct. at 3¼% | 1.04 |
| Annual repairs | 2.00 |
| Total cost | 7.80 |

### ASPHALTIC OR BITUMINOUS CONCRETE.

2½ in. thick on 6-in. concrete base.

Assumption.—Useful life of wearing surface, 20 years; top, 2½ in. thick; Borough of Bronx specifications.

| | Per sq. yd. |
|---|---|
| Cost of concrete base 6 in. thick | $0.80 |
| Cost of wearing surface 2½ in. thick | .70 |
| Total | $1 50 |
| Annual repairs | 2.35 ct. |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $1.50 at 4¼% | 6.375 |
| Amortization on top, 70 ct. at 3¼% | 2.275 |
| Annual repairs | 2.35 |
| | 11.00 |
| Total | 11.00 |

### SHEET ASPHALT.

3 in. thick on 6-in. concrete base.

Assumptions.—Useful life of wearing surface, 25 years; top, 3 in. thick; Borough of Manhattan specifications.

| | Per sq. yd |
|---|---|
| Cost of concrete base 6 in. thick | $0.80 |
| Cost of wearing surface 3 in. thick | .90 |
| Total | $1.70 |
| Annual repairs | 2 ct. |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $1.70 at 4¼% | 7.225 |
| Amortization on top, 90 ct. at 2¼% | 2.025 |
| Annual repairs | 2.00 |
| Total | 11.25 |

### BRICK.

4 in. thick on concrete base.

Assumptions.—Useful life of wearing surface, 25 years.

| | Per sq. yd. |
|---|---|
| Cost of wearing surface (N. Y. State) | $1.20 |
| Cost of 6-in. concrete base | .80 |
| Total | $2.00 |
| Annual repairs | 2 ct. |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $2.00 at 4¼% | 8.5 |
| Amortization on top, $1.20 at 3¼% | 3.9 |
| Annual repairs | 2.0 |
| Total | 14.0 |

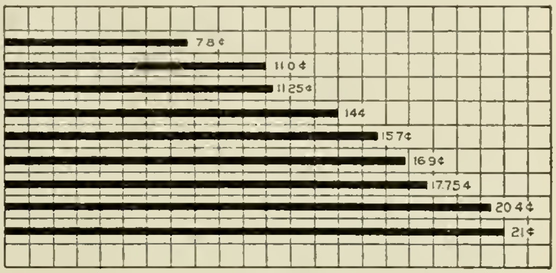
### BITUMINOUS MACADAM.

Assumptions.

| | Per sq. yd. |
|---|---|
| Cost of pavement | $0.871 |
| Annual repairs of pavement | .121 |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $0.871 at 4¼% | 3.7 |
| Annual repairs | 12.0 |
| Total | 15.7 |



GROSS ANNUAL COST PER SQ YD. OF VARIOUS MATERIALS

### ASPHALT BLOCK.

2½ in. thick on 6-in. concrete base.

Assumptions.—Useful life of 2½-in. wearing surface, 20 years.

| | Per sq. yd. |
|---|---|
| Cost of wearing surface | $1.40 |
| Cost of concrete base 6 inches thick | .80 |
| Total | $2.20 |
| Annual repairs | 3 ct. |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $2 20 at 4¼% | 9.35 |
| Amortization on wearing surface, $1.40 at 3¼% | 4.55 |
| Annual repairs | 3.00 |
| Total | 16.9 |

### WATERBOUND MACADAM.

| | Per sq. yd. |
|---|---|
| Cost of pavement | $0.648 |
| Annual repairs | .15 |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, 64.8 ct. at 4¼% | 2.75 |
| Repairs | 15.00 |
| Total | 17.75 |

### WOOD BLOCK.

3 in. thick on 6-in. concrete base.

Assumptions.—Useful life of wearing surface, 20 years.

| | Per sq. yd. |
|---|---|
| Cost of wearing surface | $2.00 |
| Cost of concrete base 6 in. thick | .80 |
| Total | $2.80 |
| Annual repairs | 2 ct. |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $2.80 at 4¼% | 11.90 |
| Amortization on wearing surface, $2.00 at 3¼% | 6.50 |
| Annual repairs | 2.00 |
| Total | 20.4 |

### GRANITE BLOCK.

4 in. thick on 6-in. concrete base.

Assumptions.—Useful life of wearing surface, 35 years.

| | Per sq. yd. |
|---|---|
| Cost of wearing surface | $3.00 |
| Cost of 6-in. concrete base | .80 |
| Total | $3.80 |
| Annual repairs | 1 ct. |

Gross Annual Cost per Square Yard.

| | Ct. |
|---|---|
| Interest charge on pavement, $3.80 at 4¼% | 16.15 |
| Amortization on wearing surface, $3.00 at 1.28% | 3.85 |
| Annual repairs | 1.00 |
| Total | 21.0 |

### SUMMARY OF COST.

The following table shows gross annual cost per square yard, including interest on first cost, plus amortization, plus annual repairs:

| | Kind. | Annual cost per sq. yd. in cents. |
|---|---|---|
| 1. | Concrete | 7.8 |
| 2. | Asphaltic concrete on 6-in. concrete base | 11 |
| 3. | Sheet asphalt on 6-in. concrete base | 11.25 |
| 4. | Brick on 6-in. concrete base | 14 |
| 5. | Bituminous macadam | 15.7 |
| 6. | Asphalt block | 16 9 |
| 7. | Waterbound macadam | 17.75 |
| 8. | Wood block | 20.4 |
| 9. | Granite block | 21 |

From the above we see that the concrete pavement costs 7.8 ct. per square yard per year, and that next to this asphaltic concrete costs 11 ct. per square yard per year, or about 40 per cent more; bituminous macadam, 15.7 ct. per square yard, or double as much; and water-bound macadam, 17¾ ct. per square yard, or over 2¼ times as much.

My figures as to maintenance cost of the asphaltic concrete and sheet asphalt presuppose that the community owns its own asphalt repair plant and that the maintenance organization is highly skilled and thoroughly efficient and extremely prompt. Without this, the figures should be very much increased, as the upkeep will be considerably higher, and the life of the pavement shortened. This is not the case with concrete pavements, as no expensive plant of any kind is required; therefore, the figures given for their maintenance should easily be met in any locality.

As I said before, the age of these various pavements and the cost of future maintenance per year are more or less elements of uncertainty. This is not the case, however, with such types as bituminous macadam and water-bound macadam. So many miles of these have been laid in recent years that we have accurate data both as to the first costs of these pavements and as to the annual cost of repairs. The figures I have given are believed to be not above the average.

It may be objected that the concrete pavement cannot be easily repaired in case the pavement has to be cut for installing subsurface pipes or making repairs to subsurface structures. This objection is a valid one and until we find a method of easily making a thoroughly first-class patch it might seem desirable not to use a concrete pavement where, in a rapidly growing community, numerous cuts must be made in the surface.

In places where the probability of making numerous cuts is remote, it might be desirable to build the pavement, say, 2 in. lower than the final proper surface of the roadway; then when the surface has become too much marred by cuts in the course of years, it could be used as a foundation for a top of bituminous concrete, sheet asphalt, asphalt blocks or brick. The economies resulting from this method would be that for a number of years the concrete pavement would be very serviceable and entail a low first cost on the community.

The question of the facility of making repairs in pavements due to cuts required for the installation of subsurface structures, is an extremely important one, and cannot be ignored.

It would of course be extremely desirable if in growing communities the subsurface structures were placed in such a way as to avoid cutting into the pavement for repairs and connections; and there is no doubt that were this done not only would the life of the pavement be very materially increased, but the comfort and convenience of the community would also be conserved. Unfortunately, however, this is not being done. The highway engineer must, therefore, make the best of the existing situation.

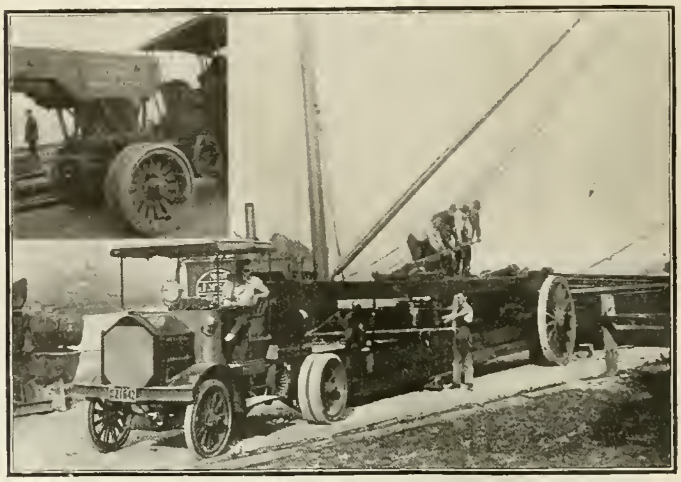
## HAULING STRUCTURAL STEEL IN NEW YORK CITY.

Contributed by Knox Motor Associates, Springfield, Mass.

The Goodman Contracting Co. makes a specialty of hauling structural steel—a commodity which, because of its weight and length, is well calculated to test the endurance of motor equipment. At the present time Mr. Goodman is hauling this steel by the tractor and trailer method,—letting his power plant serve as a "gasoline horse" which can be attached and detached to his loads at will. The power vehicle selected by Mr. Goodman was a Knox tractor. Mr. Goodman considered that aside from the tractor's ability to haul loads weighing from 15 to 20 tons the big advantage was the saving of time. In two or three minutes the tractor can be detached from the swing truck semi-trailer so that the tractor itself can be used with whatever type of semi-trailer is best adapted to the particular load to be moved.

At night the semi-trailers are left in the yard while the tractor itself is housed in a garage. The coupling and uncoupling of the tractor and semi-trailer is a simple matter, the rear of the tractor and front of the trailer being fitted with a rim-bearing center-pin turn-table. A bolt engaging a slot in the center pin holds the trailer in place. To uncouple, a jack is set under the front of the trailer which is raised until the pin clears the tractor. The tractor is then driven off and a light horse placed under the front of the semi-trailer for the night. In the morning the process is reversed.

Mr. Goodman has found the swing truck semi-trailer greatly superior to the platform truck type for hauling heavy steel, as it does not have to wait at either end for a derrick to load and unload. It can take up and drop its own loads in a few minutes. Moreover, the large diameter of its wheels gives a distinct advantage in the reduction of impact and also of the traction required on rough streets.



Special Truck for Hauling Structural Steel.

Experience has proved the tractor and trailer method to be a great saving over horse-drawn trucks. The tractor makes many more trips per day and negotiates steep grades without difficulty. In connection with apartment house construction work the tractor has hauled 10 and 15-ton loads from the 96th Street dock to West End Ave. The Highway Department of New York City states that 158th Street hill is an 8.17 grade—over 8 ft. rise per 100 ft.—which is a severe test for a 15-ton load.

Summing up his views on the tractor and semi-trailer method, Mr. Goodman says: "We find that the tractor will handle work we would not dare put on a truck. It is easy to manipulate in heavy traffic, and no matter how heavy the load or how steep the hill there is always power plus. We can say without hesitation that this method of hauling our structural steel has greatly increased the productivity of our equipment.

## SOME COMPARATIVE TESTS OF WIRE-CUT-LUG AND REPRESSED PAVING BRICK.

Contributed by Wm. A. Goss.*

Paving brick commonly have projections or lugs upon their sides, the object of which is to produce separation between the brick courses in a pavement, and make it possible to pour an elastic or grout filler into the cracks. The essential difference between wire-cut-lug and repressed pavers lies in the method of forming these lugs. Those on the wire-cut-lug brick are made by using a special type of wire-cutter, which operates through deflecting plates, cutting ridges or lugs upon the joint face of the brick. Those on the repressed are formed by remolding under pressure, using special molds shaped to form knobs on the joint face. Repressing is commonly believed to produce a partial rearrangement in the internal structure to the brick. It is the purpose of these tests to determine what effect this change in structure has upon their quality.

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*Employed by F. J. Bachelder, Consulting Engineer on work with the Chicago Traction and Subway Commission.

These tests were carried on in the testing laboratory at the University of Wisconsin during the winter and spring of 1915. All brick used in the tests were obtained at the same plant in order that there might be no difference in the materials from which they were made. Care was taken to select brick from the same part of the furnace, in order that difference in degree of burning might not affect the results.

Standard abrasion tests, made on both types of brick, gave the results shown in Table I. They show that both types of brick have equally good abrasive qualities.

TABLE I.—STANDARD ABRASION TESTS.

| Sample No. | Type of brick. | Weights of brick. Original. Lb. | Weights of brick. Final. Lb. | Loss in weight. Lb. | Loss in weight. Per cent. |
|---|---|---|---|---|---|
| 1 | Repressed .......... | 89.50 | 73.44 | 16.06 | 18.6 |
| *2 | Repressed .......... | 89.88 | 72.62 | 17.26 | 19.2 |
| | Average .................................... | | | | 18.90 |
| 1 | Wire-cut-lug ....... | 92.75 | 75.06 | 17.69 | 19.1 |
| 2 | Wire-cut-lug ....... | 92.50 | 75.12 | 17.38 | 18.8 |
| | Average .................................... | | | | 18.95 |

*One brick broken.

Abrasion tests were also made, which were standard in every respect, except that the rattler was stopped at regular intervals and weights taken. This was done in order to determine the manner in which the losses progress during the rattler test. The results of this test are given in Table II, and curves plotted from these results are shown in Fig. 1.

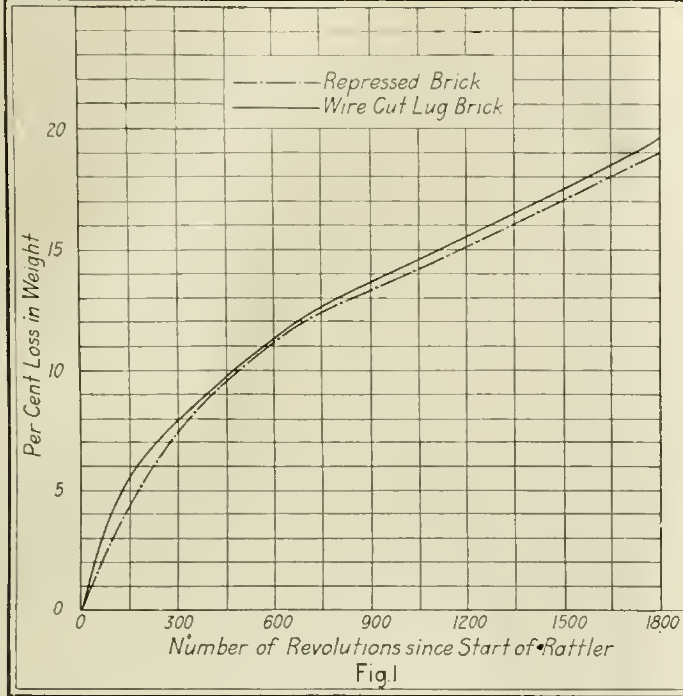


Fig. 1—Curves Showing Progressive Loss of Wire-cut-lug and Repressed Brick in the Rattler.

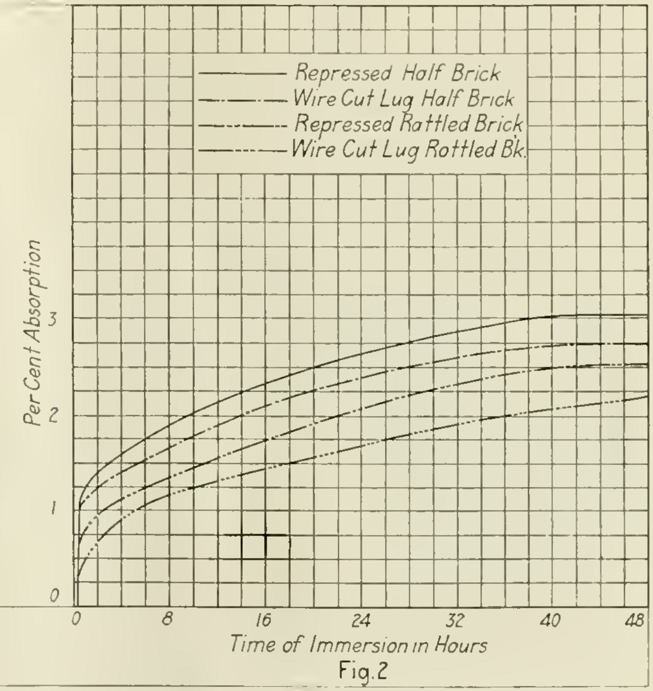


Fig. 2—Absorption Curves for Rattled and Half Brick, Comparing Qualities of Repressed and Wire-cut-lug Pavers.

TABLE II.—PROGRESSIVE LOSS IN THE RATTLER.

| Sample No. | Type of brick. | Revolution weighed at. | Weights brick. | Loss in weight. Lb. | Loss in weight. Per cent. |
|---|---|---|---|---|---|
| 1 | Repressed ......... | Initial | 89.56 | ..... | .... |
| | | 150 | 85.31 | 4.25 | 4.7 |
| | | 450 | 80.00 | 9.56 | 10.7 |
| | | 750 | 77.37 | 12.19 | 13.6 |
| | | 1,050 | 75.50 | 14.06 | 15.7 |
| | | 1,350 | 73.88 | 15.68 | 17.4 |
| | | 1,800 | 71.56 | 18.00 | 20.3 |
| 2 | Repressed ......... | Initial | 89.94 | ..... | ... |
| | | 232 | 84.00 | 5.94 | 6.6 |
| | | 450 | 81.81 | 8.13 | 9.0 |
| | | 750 | 79.94 | 10.00 | 11.1 |
| | | 1,050 | 78.06 | 11.88 | 13.2 |
| | | 1,350 | 76.56 | 13.38 | 14.9 |
| | | 1,800 | 74.19 | 15.75 | 17.5 |
| 1 | Wire-cut-lug ...... | Initial | 93.00 | ..... | .... |
| | | 150 | 88.25 | 4.75 | 5.1 |
| | | 450 | 83.69 | .9.31 | 10.0 |
| | | 750 | 81.37 | 11.63 | 12.5 |
| | | 1,050 | 79.31 | 13.69 | 14.2 |
| | | 1,350 | 77.50 | 15.50 | 16.7 |
| | | 1,800 | 75.06 | 17.94 | 19.3 |
| *2 | Wire-cut-lug ...... | Initial | 92 94 | ..... | .... |
| | | 150 | 87.50 | 5.44 | 5.8 |
| | | 450 | 83.88 | 9.06 | 9.8 |
| | | 750 | 81.31 | 11.63 | 12.5 |
| | | 1,050 | 79.56 | 13.38 | 14.5 |
| | | 1,350 | 77.50 | 15.44 | 16.6 |
| | | 1,800 | 74.50 | 18.44 | 19.9 |

*One brick broken in last 450 revolutions.

An examination of these curves shows a more rapid wear on the wire-cut-lug brick during the first 150 revolutions than on the repressed brick. During the next 300 revolutions the wear on the repressed brick is most rapid, while during the remainder of the test there is little difference in wear on the two kinds of brick. The more rapid wear at the beginning of the test is expected, for it is natural that the sharp edges of the wire-cut-lug brick should wear faster than the round edges of the repressed. That they do not wear as rapidly during the next few hundred revolutions, indicates that the surface of the wire-cut-lug brick is tougher than that of the repressed.

Standard absorption tests made on both rattled and half brick gave the results in Tables III and IV, and curves plotted from these results are shown in Fig. 2.

The first thing evident from these results is that the rattled brick do not absorb water as fast as the half brick. The large amount of fine dust which is produced during the rattler test tends to fill the pores in the brick, and to retard absorption.

The tests on half brick indicate better what may be expected when brick are exposed to the weather in a pavement. The absorption during the first half hour of the test is considerably greater for the repressed brick than for the wire-cut-lug. This indicates that the pore spaces in the repressed brick are larger and more readily penetrable than those in the wire-cut-lug. The final absorption of the repressed brick is greater than that of the wire-cut-lug, and indicates that the latter have not as great a percentage of pore space, and that they are of a more dense structure than the repressed brick.

Specific gravity tests, made on the half brick used for the absorption tests, gave the results in Table V. The

TABLE III.—ABSORPTION TESTS ON RATTLED BRICK.

| Sample No. | Type of brick. | Weight in lb. after immersion for— Dry. | ½ hr. | 6 hr. | 24 hr. | 48 hr. | Per cent Absorption after— ½ hr. | 6 hr. | 24 hr. | 48 hr. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Repressed ..... | 7.46 | 7.55 | 7.59 | 5.69 | 7.72 | 1.206 | 1.742 | 3.084 | 3.486 |
| 2 | Repressed ...... | 6.99 | 7.03 | 7.04 | 7.06 | 7.09 | 0.572 | 0.715 | 1.002 | 1.431 |
| 3 | Repressed ...... | 7.50 | 7.57 | 7.61 | 7.70 | 7.74 | 0.934 | 1.467 | 2.667 | 3.201 |
| 4 | Repressed ...... | 7.58 | 7.62 | 7.66 | 7.71 | 7.75 | 0.522 | 1.056 | 2.246 | 2.245 |
| 5 | Repressed ...... | 7.37 | 7.42 | 7.45 | 7.50 | 7.53 | 0.675 | 1.083 | 1.763 | 2.172 |
| | Average ............................... | | | | | | 0.704 | 1.213 | 2.132 | 2.507 |
| 1 | Wire-cut-lug .. | 7 05 | 7.08 | 7.10 | 7.14 | 7.19 | 0.266 | 0.704 | 1.276 | 1.973 |
| 2 | Wire-cut-lug .. | 7.64 | 7.68 | 7.74 | 7.79 | 7.85 | 0.523 | 1.308 | 1.963 | 2.750 |
| 3 | Wire-cut-lug .. | 7.56 | 7.60 | 7.66 | 7.71 | 7.73 | 0.528 | 1.323 | 1.985 | 2.250 |
| 4 | Wire-cut-lug .. | 7.82 | 7.87 | 7.95 | 7.99 | 8.03 | 0.641 | 1.662 | 2.173 | 2.683 |
| 5 | Wire-cut-lug .. | 7.57 | 7.59 | 7.61 | 7.65 | 7.68 | 0.264 | 0.528 | 1.053 | 1.453 |
| | Average ............................... | | | | | | 0.444 | 1.105 | 1.690 | 2.222 |

TABLE IV.—ABSORPTION TESTS ON HALF BRICK.

| Sample No. | Type of brick. | Weight in lb. after immersion for— Dry. | ½ hr. | 6 hr. | 24 hr. | 48 hr. | Per cent absorption after— ½ hr. | 6 hr. | 24 hr. | 48 hr. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Repressed | 4.72 | 4.78 | 4.79 | 4.83 | 4.84 | 1.271 | 1.482 | 2.330 | 2.541 |
| 2 | Repressed | 4.65 | 4.72 | 4.74 | 4.80 | 4.81 | 1.505 | 1.935 | 3.227 | 3.411 |
| 3 | Repressed | 3.94 | 3.98 | 4.02 | 4.07 | 4.09 | 1.013 | 2.032 | 3.303 | 3.808 |
| 4 | Repressed | 4.75 | 4.81 | 4.84 | 4.88 | 4.90 | 1.262 | 2.894 | 2.735 | 3.158 |
| 5 | Repressed | 4.66 | 4.71 | 4.72 | 4.75 | 4.77 | 1.073 | 1.288 | 1.933 | 2.362 |
|  | Average |  |  |  |  |  | 1.225 | 1.726 | 2.707 | 3.062 |
| 1 | Wire-cut-lug | 4.41 | 4.47 | 4.49 | 4.52 | 4.55 | 1.362 | 1.815 | 2.497 | 3.179 |
| 2 | Wire-cut-lug | 4.78 | 4.83 | 4.87 | 4.90 | 4.91 | 1.047 | 1.882 | 2.512 | 2.722 |
| 3 | Wire-cut-lug | 4.32 | 4.37 | 4.38 | 4.40 | 4.43 | 1.157 | 1.388 | 1.848 | 2.550 |
| 4 | Wire-cut-lug | 5.43 | 5.49 | 5.50 | 5.54 | 5.56 | 1.252 | 1.290 | 2.028 | 2.395 |
| 5 | Wire-cut-lug | 4.79 | 4.83 | 4.85 | 4.89 | 4.91 | 0.835 | 1.252 | 2.087 | 2.502 |
|  | Average |  |  |  |  |  | 1.131 | 1.525 | 2.194 | 2.670 |

TABLE V.—SPECIFIC GRAVITY TESTS.

| Sample. No. | Type of brick. | Weights in lb. Dry. | Wet. | Under water. | Specific gravity. |
|---|---|---|---|---|---|
| 1 | Repressed | 4.72 | 4.84 | 2.77 | 2.279 |
| 2 | Repressed | 4.65 | 4.81 | 2.76 | 2.318 |
| 3 | Repressed | 3.94 | 4.09 | 2.35 | 2.265 |
| 4 | Repressed | 4.75 | 4.90 | 2.83 | 2.294 |
| 5 | Repressed | 4.66 | 4.77 | 2.72 | 2.322 |
|  | Average |  |  |  | 2.296 |
| 1 | Wire-cut-lug | 4.41 | 4.55 | 2.62 | 2.282 |
| 2 | Wire-cut-lug | 4.78 | 4.91 | 2.77 | 2.234 |
| 3 | Wire-cut-lug | 4.32 | 4.43 | 2.51 | 2.250 |
| 4 | Wire-cut-lug | 5.43 | 5.46 | 3.14 | 2.242 |
| 5 | Wire-cut-lug | 4.79 | 4.91 | 2.75 | 2.208 |
|  | Average |  |  |  | 2.243 |

repressed brick have a slightly higher specific gravity, which means that the solid matter in the repressed brick weighs more per unit volume than that in the wire-cut-lug. This difference is slight, however, and might easily be caused by the method of repressing, for the pressure used in repressing is probably sufficient to condense that portion of the brick at the surface, and cause it to have a slightly higher specific gravity than the inner part of the brick.

Standard cross-bending tests, made on the two types of brick, gave the results in Table VI. These results favor the repressed brick, and are explained by a consideration of the manner in which the repressing is done. The brick are placed flatwise in the repress molds, and the pressure is exerted vertically, tending to change the internal structure and to produce planes or laminae of strength perpendicular to the direction of pressure. An example of the results of this kind of action is found in the formation of slate and shale, only that in their case the pressure is many times greater, and the process of forming planes is carried to a far greater degree of completion. These planes or laminae would add to the strength of the brick when tested in a direction at right angles to that in which they were orginally formed. As this was the direction of the force in the tests, the results obtained are such as to be expected.

TABLE VI.—CROSS-BENDING TESTS.

| Sample. No. | Type of brick. | Dimensions, in inches. Width. | Depth. | Span. | Load, in lb. | Modulus of rupture. |
|---|---|---|---|---|---|---|
| 1 | Repressed | 3.35 | 3.83 | 7 | 7,990 | 1,708 |
| 2 | Repressed | 3.33 | 3.95 | 7 | 8,390 | 1,699 |
| 3 | Repressed | 3.40 | 3.90 | 7 | 8,000 | 1,621 |
| 4 | .Repressed | 3.30 | 3.90 | 7 | 10,720 | 2,242 |
| 5 | Repressed | 3.45 | 3.80 | 7 | 9,280 | 1,935 |
|  | Average |  |  |  |  | 1,841 |
| 1 | Wire-cut-lug | 3.65 | 3.87 | 7 | 7,760 | 1,488 |
| 2 | Wire-cut-lug | 3.62 | 3.87 | 7 | 7,530 | 1,457 |
| 3 | Wire-cut-lug | 3.62 | 3.76 | 7 | 7,380 | 1,510 |
| 4 | Wire-cut-lug | 3.62 | 3 90 | 7 | 8,510 | 1,617 |
| 5 | Wire-cut-lug | 3.60 | 3.80 | 7 | 7,280 | 1,435 |
|  | Average |  |  |  |  | 1,501 |

Compression tests, made on both types of brick, gave the results in Table VII. These favor the wire-cut-lug brick, and indicate that the arrangement in the internal structure of the brick, due to repressing, has reduced the internal cohesion, and the strength as a result. This test is not of great value for comparing the brick, as the other components of a brick pavement would always fail long before the crushing strength of the brick was reached.

TABLE VII.—COMPRESSION TESTS.

| Sample No. | Type of brick. | Dimensions in inches. Width. | Length. | Load at failure. | Compressive strength in lbs. per sq. in. |
|---|---|---|---|---|---|
| 1 | Repressed | 3.30 | 4.30 | 88,000 | 6,190 |
| 2 | Repressed | 3.40 | 4.50 | 138,500 | 9,060 |
| 3 | Repressed | 3.30 | 4.40 | 104,000 | 7,180 |
| 4 | Repressed | 3.35 | 3.90 | 87,500 | 6,680 |
| 5 | Repressed | 3.30 | 1.30 | 158,000 | 11 130 |
|  | Average |  |  |  | 8,050 |
| 1 | Wire-cut-lug | 3.50 | 4.30 | 126,000 | 8,400 |
| 2 | Wire-cut-lug | 3 60 | 4.50 | 154,000 | 9,510 |
| 3 | Wire-cut-lug | 3.50 | 4.00 | 103,500 | 7,390 |
| 4 | Wire-cut-lug | 3.50 | 3.70 | 150,500 | 11,680 |
| 5 | Wire-cut-lug | 3.60 | 4.40 | 111,500 | 7,060 |
|  | Average |  |  |  | 8,810 |

Shear tests were made, using a single shear method. The brick were clamped firmly in a fixture in such a manner that one end of the brick projected about an inch. A vertical pressure, exerted upon this projecting end, was continued until failure took place. The results of this test are shown in Table VIII, and there is practically no difference between the brick.

TABLE VIII.—SINGLE SHEAR TESTS.

| Sample No. | Type of brick. | Dimensions in inches. Width. | Depth. | Load, lb. | Shearing strength in lbs. per sq. in. |
|---|---|---|---|---|---|
| 1 | Repressed | 3.30 | 3.90 | 21,700 | 1,689 |
| 2 | Repressed | 3.35 | 3.75 | 21,300 | 1,698 |
| 3 | Repressed | 3.40 | 4.80 | 16,800 | 1,301 |
| 4 | Repressed | 3.35 | 4.40 | 13,200 | 985 |
| 5 | Repressed | 3.45 | 3.85 | 20,100 | 1,516 |
|  | Average |  |  |  | 1,438 |
| 1 | Wire-cut-lug | 3.60 | 3.75 | 22,700 | 1,682 |
| 2 | Wire-cut-lug | 3.60 | 3.95 | 17,100 | 1,202 |
| 3 | Wire-cut-lug | 3.60 | 3.80 | 20,200 | 1,477 |
| 4 | Wire-cut-lug | 3.55 | 3.80 | 17,600 | 1,304 |
| 5 | Wire-cut-lug | 3.60 | 3.75 | 18,300 | 1,375 |
|  | Average |  |  |  | 1,404 |

Impact tests were made, using the "Russel Impact Machine." This machine consists of a cast iron pendulum, free to swing within a supporting frame, and having a graduated arc for measuring the angle of swing. An initial angle was determined by trial, dropped from which the pendulum would just break the brick. An 8-in. span was used and the initial and final angles were recorded for each specimen broken. The results are calculated in terms of the energy of rupture consumed in breaking the brick. These results are given in Table IX, and are decidedly in favor of the repressed brick. They indicate that the repressed brick are tougher than the wire-cut-lug, and substantiate the results obtained in the cross-bending tests. They are to be explained because of the structure of the brick, as was the case in the cross-bending results.

TABLE IX.—IMPACT TESTS.

| Sample No. | Type of brick. | Dimensions in inches. Width. | Depth. | Span. | Initial angles. | Final angles. | Energy of rupture in— In lb. | In lb. per cu. in. |
|---|---|---|---|---|---|---|---|---|
| 1 | Repressed | 3.35 | 3.87 | 8 | 30° 09′ | 12° 21′ | 463 | 4.47 |
| 2 | Repressed | 3.38 | 3.90 | 8 | 30° 17′ | 18° 18′ | 350 | 3.32 |
| 3 | Repressed | 3.35 | 3.98 | 8 | 30° 30′ | 10° 21′ | 472 | 4.43 |
| 4 | Repressed | 3 38 | 3.97 | 8 | 30° 18′ | 20° 37′ | 294 | 2.74 |
| 5 | Repressed | 3.42 | 3.87 | 8 | 30° 02′ | 19° 28′ | 335 | 3.07 |
| 6 | Repressed | 3.39 | 3.93 | 8 | 30° 38′ | 12° 31′ | 470 | 4.41 |
|  | Average |  |  |  |  |  |  | 3.73 |
| 1 | Wire-cut-lug | 3 10 | 3.81 | 8 | 21° 00′ | 6° 30′ | 246 | 2.35 |
| 2 | Wire-cut-lug | 3.64 | 3.87 | 8 | 20° 27′ | 3° 42′ | 253 | 2.22 |
| 3 | Wire-cut-lug | 3.66 | 3.82 | 8 | 19° 42′ | 4° 47′ | 228 | 2.04 |
| 4 | Wire-cut-lug | 3.68 | 3.78 | 8 | 19° 53′ | 8° 42′ | 188 | 1.78 |
| 5 | Wire-cut-lug | 3.60 | 3.90 | 8 | 24° 23′ | 12° 11′ | 275 | 2.45 |
| 6 | Wire-cut-lug | 3.71 | 3.93 | 8 | 20° 00′ | 5° 08′ | 234 | 2.01 |
|  | Average |  |  |  |  |  |  | 2.13 |

The determinations arrived at as a result of these tests are that the wire-cut-lug bricks have—

1. Better abrasive and wearing qualities.
2. Greater density.
3. Greater crushing strength.

The repressed brick have

1. Greater weight per unit volume.
2. Greater toughness.

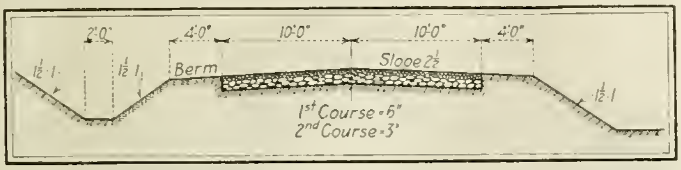
An examination of the various tests shows in addition that the wire-cut-lug brick are of more uniform quality than the repressed.

The tests show that both types of the brick tested were of good quality for paving purposes. Either brick is plenty strong and tough enough for use in a pavement. The difference in wearing qualities and in uniformity are the most important determinations of these tests, and in these characteristics the wire-cut-lug brick have shown superiority. This difference is not marked, however, and it would be necessary to test out brick from other plants before one could state just what degree of difference exists.

These tests were conducted by W. A. Goss and W. T. Bolton, assisted by the able suggestions of Prof. L. S. Smith and Prof. M. O. Withey of the University of Wisconsin. The Dunn Wire-Cut-Lug Brick Co. was very generous in furnishing samples, and co-operated with us in every way possible.

## ASPHALT MACADAM CONSTRUCTION IN LAKE COUNTY, INDIANA.

Lake County, Indiana, has about 600 miles of improved roads, a considerable number being of asphalt macadam construction. The county is only a few miles distant from Chicago, and its highways furnish a direct connection with the park boulevard system of that city. As a consequence the automobile traffic is especially heavy.



Section of Lake County Road.

The first asphalt macadam road was built by the county in March, 1912, in North Township. The section was a trifle over 1 mile in length and the contract price was $12,964 per mile. The pavement was 12 in. thick and 24 ft. wide. One other section also was built in 1912. The county road improvement work in 1913 and 1914 was mostly macadam construction. In 1915, however, most of the work was asphalt macadam. Some details of these roads and of those constructed in previous years are given in Table I.

TABLE I.—DETAILS OF ASPHALT MACADAM CONSTRUCTION IN LAKE COUNTY, INDIANA.

| Year built. | Length, ft. | Width, ft. | Thickness, ins. | Contract price per mile. | Cost per sq. yd. | Av. haul, miles. | Cut, cu. yd. | Fill, cu. yd. |
|---|---|---|---|---|---|---|---|---|
| 3/12..... | 5,300 | 24 | 12 | $12,964 | $0.91 | ½ | 4,910 | 1,960 |
| 8/12..... | 12,765 | 24 | 12 | 16,049 | 1.14 | 1½ | 7,861 | 15,267 |
| 3/14..... | 5,820 | 20 | 9 | 10,344 | .92 | ½ | 7,000 | 2,700 |
| 3/14..... | 9,010 | 20 | 9 | 10,052 | .85 | 1 | 7,800 | 5,600 |
| 5/14..... | 9,893 | 30 | 9 | 5,508 | 1.07 | 1 | 19,500 | 4,500 |
| 6/14..... | 4,976 | 24 | 9½ | 12,021 | .87 | ½ | 2,203 | 3,107 |
| 7/14..... | 6,842 | 30 | 10 | 16,000 | .83 | ½ | 10,850 | 1,860 |
| 7/14..... | 8,138 | 20[1] | 9 | 12,558 | .94 | ¾ | 16,200 | 1,900 |
| 7/14..... | 8,761 | 20 | 9 | 12,303 | 1.04 | ¾ | 8,220 | 9,890 |
| 8/14..... | 13,322[2] | 20 | 10 | 19,408 | 1.66 | 2 | 14,100 | 26,800 |
| 2/15..... | 15,836 | 30[3] | 9 | 11,939 | .75 | 1½ | 17,426 | 11,948 |
| 2/15..... | 4,946 | 20 | 9 | 10,174 | .90 | ¾ | 15,460 | 4,860 |
| 2/15..... | 2,666 | 30[4] | 9 | 9,956 | .72 | ½ | 854 | 1,361 |
| 2/15..... | 7,483 | 24 | 9 | 12,338 | .87 | ¾ | 14,200 | 15,700 |
| 2/15..... | 2,656 | 16 | 9 | 7,400 | .77 | 1 | 1,420 | 3,010 |
| 3/15..... | 1,270 | 16 | 9 | 11,183 | 1.11 | ¾ | 6,580 | 2,465 |
| 3/15..... | 3,110 | 16 | 9 | 9,135 | .96 | ¾ | 8,500 | 7,040 |
| 3/15..... | 5,270 | 16 | 9 | 8,469 | .90 | 1 | 3,400 | 4,250 |
| 3/15..... | 6,576 | 20 | 9 | 10,401 | .87 | ¾ | 4,950 | 3,710 |
| 3/15..... | 9,663 | 16 | 9 | 8,001 | .84 | ¾ | 5,050 | 6,150 |
| 3/15..... | 4,400 | 16 | 9 | 8,677 | .87 | ½ | 7,300 | 1,100 |
| 4/15..... | 6,600 | 16 | 9 | 8,000 | .84 | ¾ | 7,000 | 3,100 |
| 4/15..... | 9,444 | 25 | 11 | 12,182 | .95 | ½ | 12,137 | 5,970 |
| 5/15..... | 10,645[5] | 45 | 4 | 17,450 | .66 | 1 | ...... | ...... |
| 5/15..... | 2,414 | 27 | 9 | 10,998 | .68 | ½ | 2,820 | 682 |
| 5/15..... | 10,240 | 16 | 9 | 8,144 | .86 | 1 | 21,420 | 5,637 |
| 5/15..... | 2,414 | 27 | 9 | 10,862 | .67 | ½ | 1,529 | 125 |
| 7/15..... | 10,161 | 20 | 9 | 11,666 | .99 | 1 | 85,740 | 4,449 |
| 7/15..... | 1,206 | 20 | 9 | 10,000 | .82 | ¾ | 47 | 1,150 |
| 7/15..... | 7,967 | 20 | 9 | 9,533 | .80 | 1 | 7,135 | 1,154 |
| 7/15..... | 3,794 | 30[4] | 9 | 13,233 | .81 | 1¼ | ...... | ...... |
| 8/15..... | 4,212 | 30 | 9 | 11,266 | .63 | ½ | 5,366 | 3,936 |
| 8/15..... | 14,520[5] | 36[6] | 3 | 10,400 | .49 | 1 | ...... | ...... |
| 8/15..... | 1,917 | 30 | 9 | 13,333 | .69 | ¾ | 148 | 3,180 |
| 8/15..... | 12,115 | 20 | 9 | 7,336 | .70 | 1 | 8,670 | 1,780 |
| 8/15..... | 2,666[5] | 45 | 3 | 13,200 | .49 | ¼ | ...... | ...... |
| 7/15..... | 9,562 | 24[1] | 9 | 10,358 | .85 | 1¼ | 8,700 | 11,400 |
| 9/15..... | 5,489 | 14 | 9 | 5,776 | .69 | ¾ | 3,240 | 1,570 |
| 9/15..... | 5,000 | 14 | 9 | ....... | ..... | ¾ | ...... | ...... |

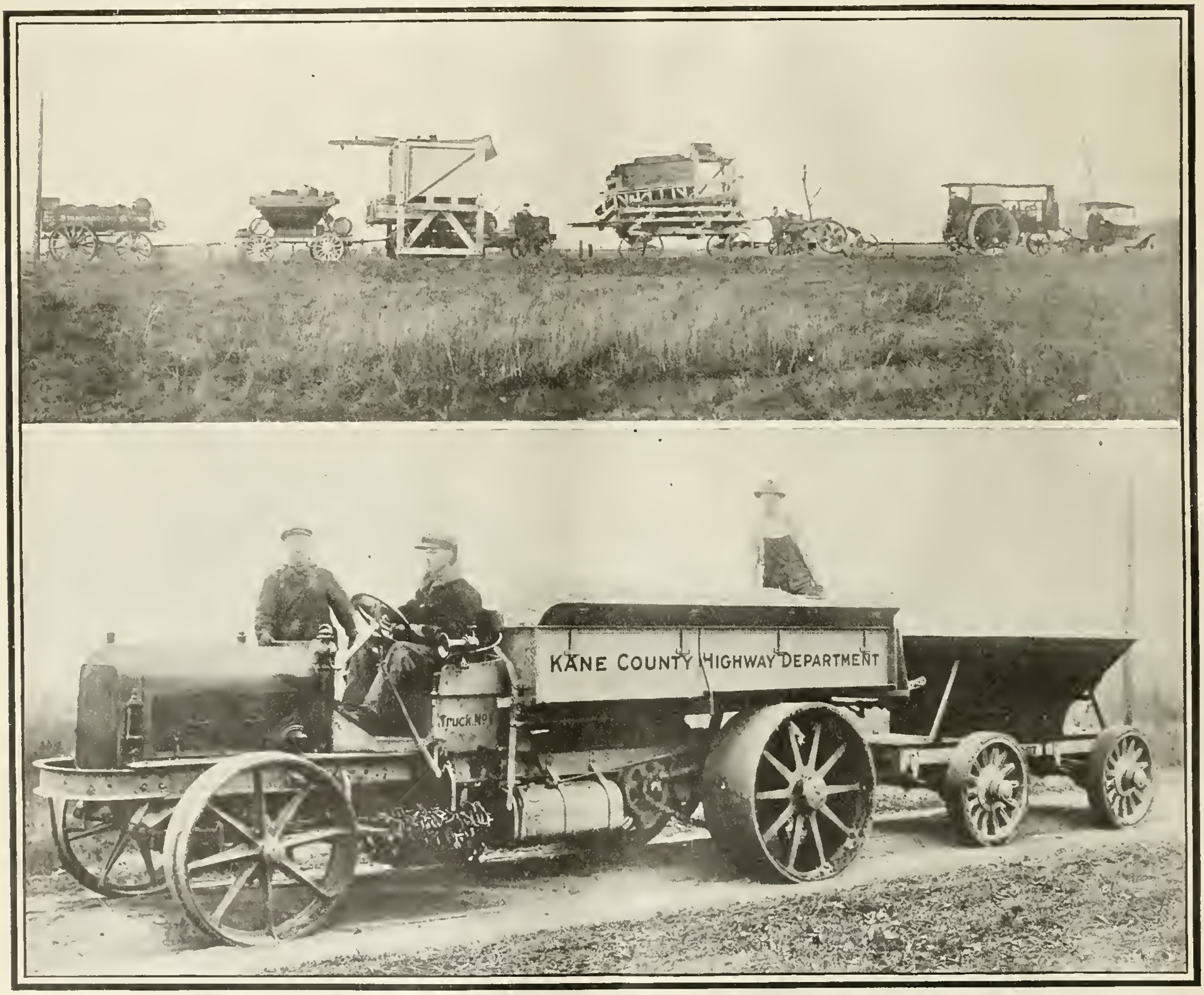
[1] 20-24 ft. [2] Includes trestle and concrete bridge. [3] 30-24 ft. [4] 30-20 ft. [5] Scarifying old road.

Construction Views of Lake County Roads.

The later asphalt macadam roads are generally built with a surface width of 20 ft. and a 9-in. surfacing. Fig. 1 shows a typical cross-section. The pavement is laid in two courses. The first course consists of 6 in. of either slag or limestone broken in sizes of from 3 in. to 4 in. and thoroughly bonded with screenings by rolling. On top of this is placed a 3-in. layer of 1½-in. to 2-in. stone which is rolled and then the asphalt applied at the rate this is placed a layer of limestone screenings of the size known as roofing screenings, and thoroughly rolled. This generally leaves a surplus of screenings on the road, which is eventually removed by traffic. In a few instances there was some variation from the general system outlined above. On South Broadway, Gary, for instance, a 4-in. wearing surface was laid and on this 2½ gal. of asphalt per square yard were applied. On most of the asphalt macadam construction Standolind paving asphalt has been used.

On the first work some difficulty was experienced in getting a uniform distribution of the asphalt, but this has been overcome by requiring the contractors to use a mechanical sprayer, which so far has proved very satisfactory, and also is an economical proposition for the contractor.

Ray Seeley is county engineer and surveyor of Lake County.



Kane County Road Construction With White Motor Trucks.

## CUTTING HAULAGE COST IN ROAD WORK TO SEVEN CENTS PER TON-MILE.*

By G. N. Lamb, County Superintendent of Highways, Kane County, Illinois.

The Forty-ninth General Assembly passed a law approved June 29, 1915, authorizing the County Boards of Supervisors to purchase machinery to enable counties to assist the respective townships in improving, repairing and maintaining township or district roads. Twenty-four days after this date the Supervisors of Kane County made an appropriation of $20,000 "for the purchase and necessary supervision of machinery for the building of township roads, the said machinery to operate under the direction of the County Superintendent of Highways and to be leased or loaned to the various townships under such rules and regulations as the Road and Bridge Committee may devise."

Prior to this time, a campaign had been conducted by the Road and Bridge Committee of the County Board and the County Superintendent of Highways to show the advantage to the road improvement throughout the county, of owning and operating such machinery. Early in the year the County Superintendent of Highways recommended this step to the Road and Bridge Committee, with whom the scheme at once met with hearty endorsement. At the March, 1915, meeting of the Supervisors he appeared before the whole board and outlined the policy to them. A short time later the Road and Bridge Committee made a trip to Indiana to look at some road construction by machinery such as was being considered suitable for the Kane County work. It was next decided to build a demonstration half mile of roadway near the central part of the county, and to accept the offer of certain companies to furnish the free use of their machinery for its construction. This road was built, and when near completion, the County Board, acting as a committee of the whole, visited the demonstration and there voted to make the appropriation, which action was later sustained by the whole board by a vote of 30 to 6.

**Selection of Machinery.**—With the fund at the disposal of the Road and Bridge Committee, the problem then presented itself of selecting the machinery that was adapted to doing the particular work which this county most needed. It was found that 79 per cent of the roads of

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*Contributed by the White Co., Cleveland, Ohio.

Kane County had been surfaced with various sorts of materials, ranging from cinders through gravel and crushed stone, to concrete or brick; and that 75 per cent of the entire road mileage was gravel. To be of the most assistance to the townships, then, the required solution of the problem was to furnish the machinery which would be useful in building better gravel roads than were possible under the old system, and at the same time cheapen the entire cost of construction. The machinery selected, therefore, was adapted to the production of gravel, properly sized, graded or crushed; to the economic transportation of gravel over country roads of all description, and to the proper formation of the road, including the subgrade as well as the finished surface.

**Apparatus for Producing Road Metal.**—It was decided to do all hauling by means of motor trucks. To do this it became necessary to design a portable gravel producing plant which had a capacity exceeding 200 cu. yd. per day, and which in loading the trucks would cause the least possible delay. A 15 cu. yd. bin was designed so as to allow the truck to drive underneath and receive its load direct from the bottom of the hopper. The bin is also designed so that in transportation it may be lowered on to the truck, the lower part of the supports first being removed and placed in the body of the truck.

On account of the unusual height of bin designed to meet motor truck requirements and to avoid having an apparatus too topheavy for transportation it was found not advisable to have the screen at its usual place at the top of the bin. The screen itself was made portable and performs the following functions: First, it separates the excess fine material, such as dirt and sand less than ⅛ in. in size, which is conveyed to a waste pile by a 12-in. 30-ft. conveyor belt; second, the gravel less than 1½ in. in size is spouted to the elevator leading to the bin; third, the gravel exceeding 1½ in. in size is directed through the crusher and then into the same elevator which carries the finer gravel. The screen and elevator are driven from the crusher, and the crusher in turn by a gasoline tractor. An 18-in. 40-ft. conveyor belt carries the gravel to a screen from a hopper which is kept supplied from the pit by means of teams with slip scrapers.

The material fed into the plant may be any grade of gravel or stone up to 9 or 10 in. in size. The finished product is a mixture of uncrushed gravel ⅛ in. to 1½ in. in size, and the entire run of the crusher set to crush to 1½ in. It is found that this product possesses excellent bonding as well as wearing qualities.

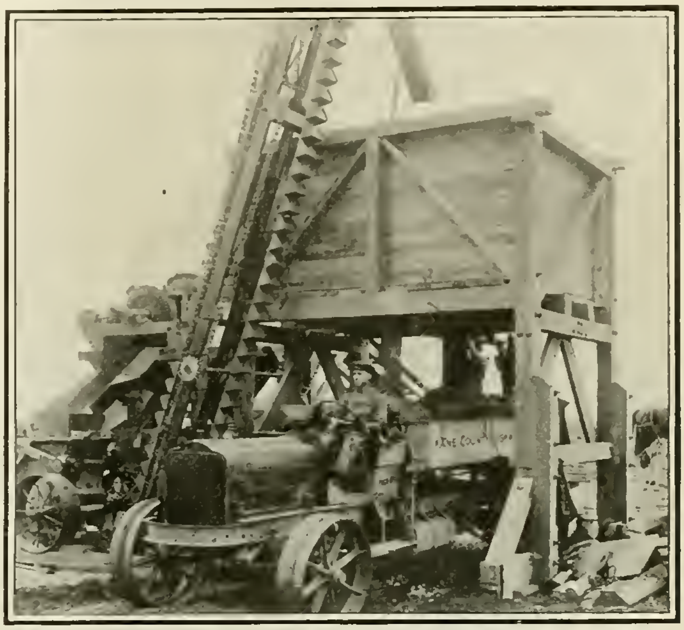
The maximum or minimum size of the entire product may be regulated by varying the size of openings in the screen and crusher.

**Transportation.**—A motor truck with a capacity of 5 cu. yd. is provided for the hauling. The truck has steel tires 10 in. wide in front and 20 in. wide in the rear. This makes a very suitable arrangement for hauling over the extremely soft ground such as was encountered in the past season's work. A 5-ton trailer also forms a part of the outfit and is suitable for use where the hauls are long and the roads are in condition to sustain the heavy loads.

**Spreading.**—The load on the truck is discharged from the rear. The storage body is first tilted, then as the truck moves forward the end gate is swung open and the gravel is evenly distributed along the subgrade. The trailer has a bottom dump arrangement operated by means of a lever and the spreading is accomplished by pulling the trailer ahead as the gravel is discharged. All the operations of discharging the truck and distributing the load are accomplished from the driver's seat. An extra man is required to discharge the trailer. When both vehicles are used the trailer is discharged first, then detached; the truck discharged, and, after turning around, hitches again to the trailer at reverse end.

**Rolling.**—The rolling is accomplished by the steel tires of the motor truck. The combined weight of the truck with a load of 5 cu. yd. is about 28,500 lbs., with 70 per cent on the rear wheels. This gives about 500 lbs. for each inch of rear tire width. The wheels are tapered; that is, the surfaces are pitched 1¼ in. so as to allow for properly crowning the road surface. The hauling is all done over the road metal as the depositing progresses and thus no cost of labor is required for the rolling. The driver must see to it that as the hauling is done all portions of the road are thoroughly rolled. It has been found advisable to deposit the material in two layers so that any unevenness which develops after the first rolling may be remedied when the second course is applied. In addition to the advantages to the road construction, it may be added here that the earth or gravel roads over which the hauling is done may be markedly improved or "ironed out" by the judicious driving of the steel-tired truck.

**Grading.**—The grading outfit consists of a 40-80 hp. gasoline tractor, a scarifier and a 12-ft. blade grader. This machinery may be used for preparing the road bed for the gravel surface, or it may be used independently for the improvement of earth roads. In this capacity, some excellent results were secured during the three months in which it was in operation. It was found that the tractor not only has power to pull the 3½-ton 12-ft. grader, but that a second grader might be attached and thereby increase the efficiency of the outfit. As an auxiliary to the grading outfit the motor truck has been used successfully as the tractive power for both scarifier and grader in tearing up old gravel roads and reshaping the subgrade prior to resurfacing with gravel.



Loading Truck From Storage Bins.

**Administration.**—No rental is charged to the townships for the use of the machinery, it being required to pay merely the operating expenses. The men operating the machines are regarded as county employes and work under instructions from the County Superintendent of Highways. The men are paid weekly from a fund deposited in a local bank at the county seat in the name of "Kane County Highway Department." The fuel, oil and supplies are also supplied by the same fund. At the end of each week a statement is sent to the township showing an itemized account of the week's expenditures by the county department for labor, gasoline, oil and other supplies. As the remittances are received from the townships the fund at the bank is replenished. The weekly statements do not include such items of labor, teams or supplies as are furnished directly by the township.

In order to keep a correct record of all cost data, daily postal card reports are made out by the man in charge of this outfit and mailed to the office of the County Superintendent of Highways. The card shows the distribution of labor and other expense of the total day's work, including men, teams, etc., furnished by the township. The data on the cards is transferred to a book of cost data and the cards filed for further reference.

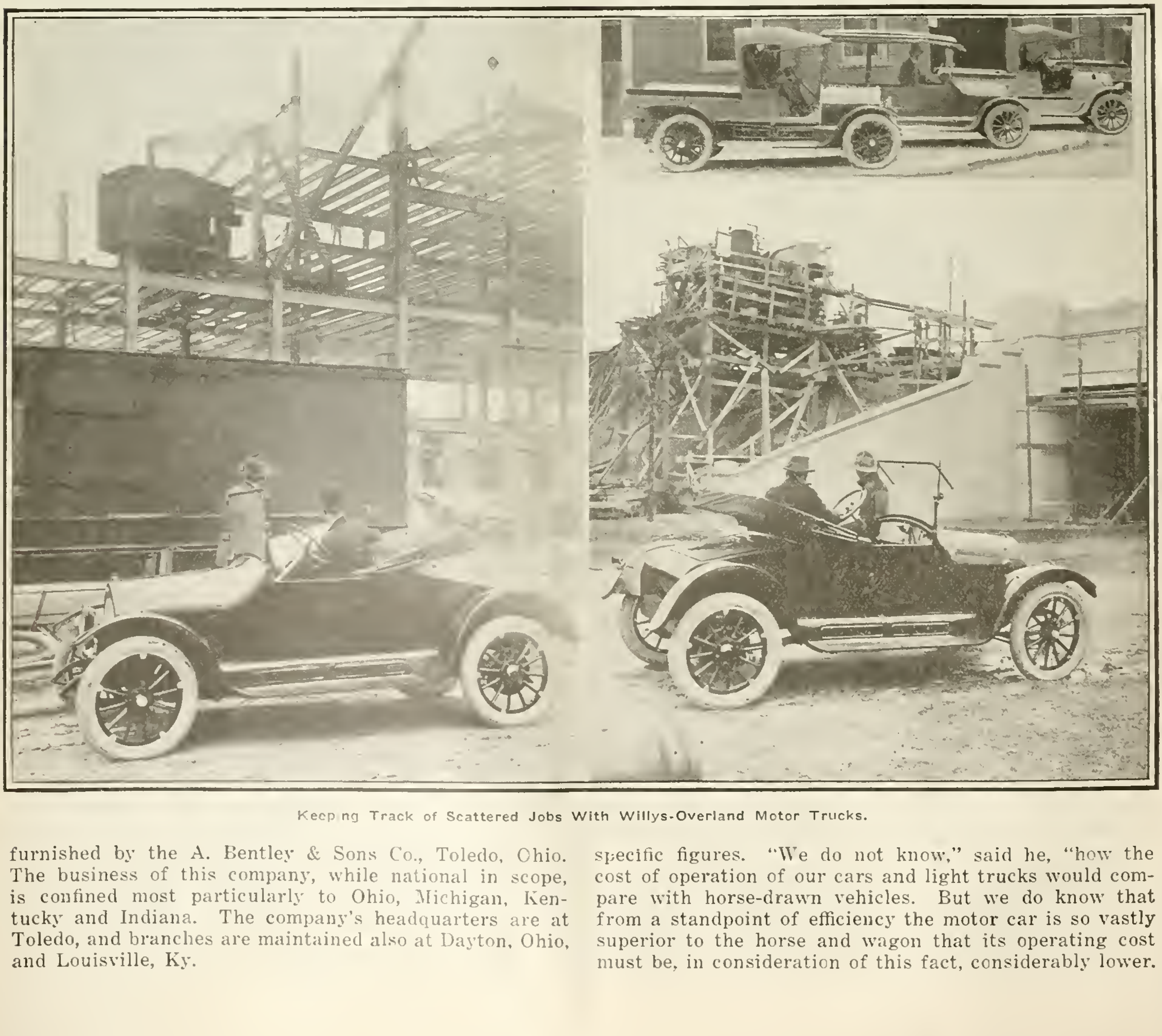
Costs.—The outfits have not been long enough in use to enable us to give accurate data. In one township the cost of grading 1.6 miles of road amounted to $43.25 per mile. The cost of loading, screening and crushing gravel in one location was about $8.90 per day, or 45 ct. per cubic yard. In another location it amounted to $17.87 per day, or 26 ct. per cubic yard; the variation being due to the length of haul. The cost of hauling gravel with the truck in one location amounted to about $7 per day, or 51 ct. per cubic yard, which, when computing the distance hauled (5 miles) was 10 ct. per yard-mile, or 7 ct. per ton-mile. In another location it amounted to $7.99 per day, or 11 ct. per cubic yard, which, when computing the distance (1 mile) was 11 ct. per yard-mile, or 7 ct. per ton-mile.

The various machines described were secured from the the following manufacturers: The motor truck from the White Company, Cleveland, Ohio; 5-ton trailer from the Troy Wagon Works Co., Troy, Ohio; the grader, scarifier, sprinkler wagon and flusher from the Austin Western Co., Chicago, Ill.; gas tractors from the Avery Co., Peoria, Ill., and the gravel handling machinery from the Stephens-Adamson Co., Aurora, Ill.

## AUTOMOBILES FOR SUPERINTENDENCE OF AND EMERGENCY DELIVERY SERVICE FOR CONSTRUCTION WORK.

Contributed by the Willys-Overland Co., Toledo, Ohio.

Interesting facts regarding the use of motor cars and motor trucks in the engineering contracting business are furnished by the A. Bentley & Sons Co., Toledo, Ohio. The business of this company, while national in scope, is confined most particularly to Ohio, Michigan, Kentucky and Indiana. The company's headquarters are at Toledo, and branches are maintained also at Dayton, Ohio, and Louisville, Ky.



Keeping Track of Scattered Jobs With Willys-Overland Motor Trucks.

The Bentley company introduced the automobile into their business in 1910, when they bought two Overland cars, a pleasure car and a coupe. Today they have in use a fleet of 14 pleasure cars and 6 light delivery cars, operating in the city of Toledo alone. The pleasure cars are used by their division superintendents and job superintendents, who are traveling from job to job and from job to company headquarters practically all of their time.

"There is no question about it; we consider both the automobile and the light delivery truck absolute necessities in our business," said Mr. L. S. Hillebrand, Secretary-Treasurer of the company, in a recent interview.

"We would no more think of conducting business without the automobile and the delivery truck than discontinuing our telephone service.

"The greatest advantage, of course, is speed. Before we adopted automobiles for this work we supplied our superintendents with horses and buggies. We were not long in discovering that a man with a car could give attention to four times as much work—and give each job closer attention.

"And the same thing applies with regard to the light delivery truck. Every contractor knows that it is the delays due to small shortages of material that cause expensive holdups—shortages that cannot be anticipated. The lack of a keg of nails, new tools, or a few bags of cement may hold up a big force of men. But the light delivery truck enables these shortages to be taken care of on such short notice that delays of this nature can be almost entirely eliminated and operating expenses greatly reduced."

As to operating costs, Mr. Hillebrand could not furnish specific figures. "We do not know," said he, "how the cost of operation of our cars and light trucks would compare with horse-drawn vehicles. But we do know that from a standpoint of efficiency the motor car is so vastly superior to the horse and wagon that its operating cost must be, in consideration of this fact, considerably lower.

"With the growth of our fleet, we established a private garage, and this is in charge of a competent mechanic. All of our cars are subjected to frequent inspection. It is estimated that one car, the coupe, during the time in service traveled more than 150,000 miles."

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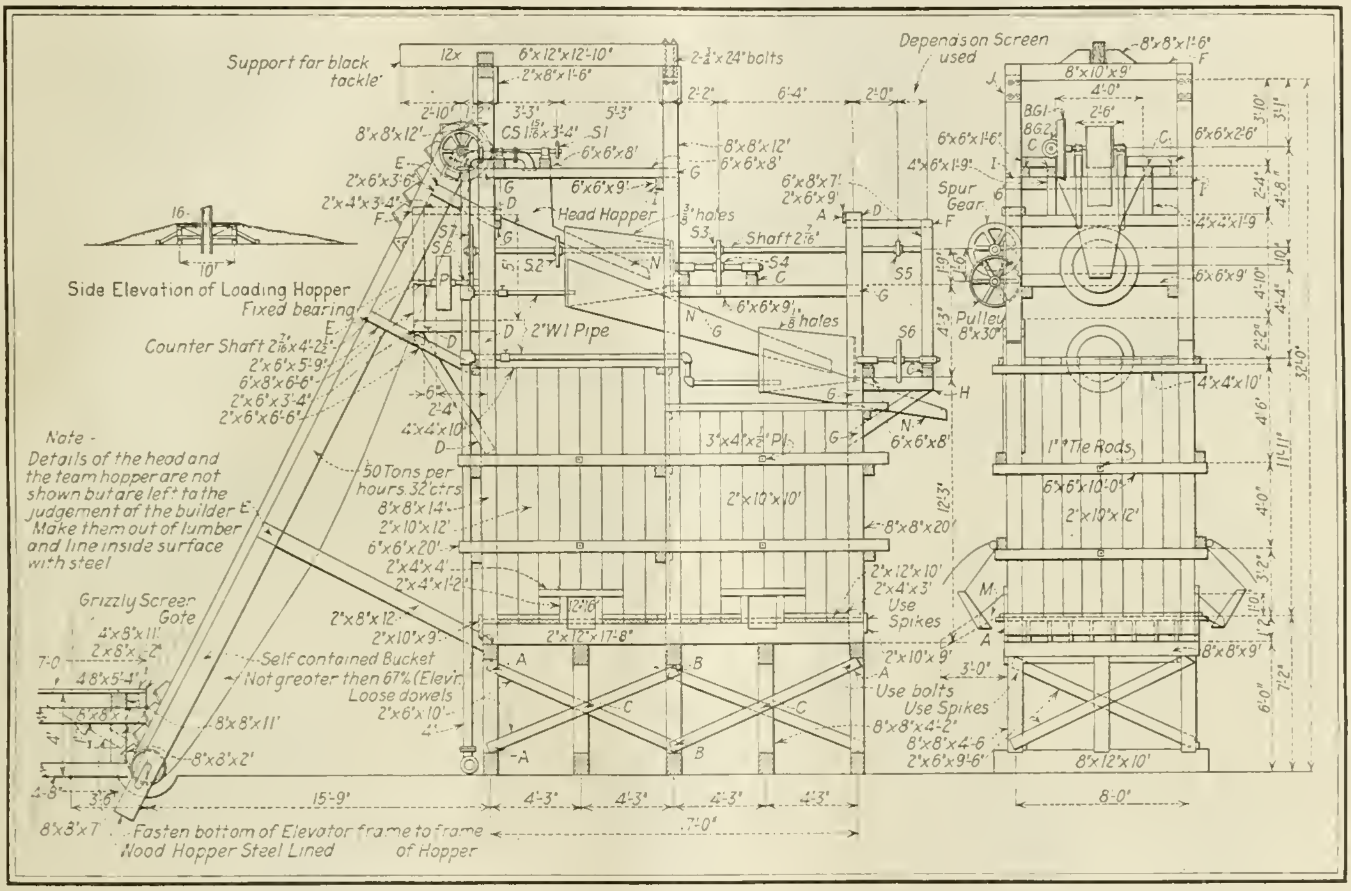
## PORTABLE WASHING PLANT FOR PREPARING AGGREGATES FOR CONCRETE ROAD CONSTRUCTION.

Contributed by H. Colin Campbell, 6536 Kenwood Ave., Chicago, Ill.

Most engineers now realize the necessity for properly selected and prepared aggregates in all concrete work. Probably no other concrete construction calls for more refinements in selecting, preparing and using concrete materials than does concrete pavement construction. Bank-run material as found in the natural deposit rarely or never contains fine and coarse materials (sand and gravel) in proper proportions for the best concrete. The material must be screened and reproportioned in correct volumes to secure maximum elimination of voids, and may also require washing to remove objectionable matter such as clay or loam. Sand and gravel are quite uniformly distributed throughout the country, and concrete road contractors could more often than they do make a nearby deposit suited to the requirements of concrete pavement if convenient facilities for screening, and in some cases washing materials were available.



Semi-Portable Gravel Screening and Washing Plant, Estimated Cost $2,000.

For this reason, the accompanying plans which represent a design for gravel screening and washing plant and details of bins will no doubt be of interest. This design has been worked out with the particular object in view of making the construction as nearly portable as possible. The general routine of preparing sand and gravel for concrete aggregate is made up of several successive steps, first of which consists of locating a deposit; next, in stripping the deposit if necessary to remove over-lying soil (unless the deposit may be worked directly out of face, which is rarely possible without stripping). Aggregates may often be obtained from river beds. After excavated, the material must be transported and elevated to a hopper which will discharge it into suitable screens receiving water under pressure from jets arranged for washing. From the screens the material passes, usually by gravity, into bins, or, in some cases, depending upon the percentage of fine material in the deposit, may be discharged into a settling tank, from which the silt-laden water flows off, allowing the sand to settle and be ultimately discharged into a receiving bin.

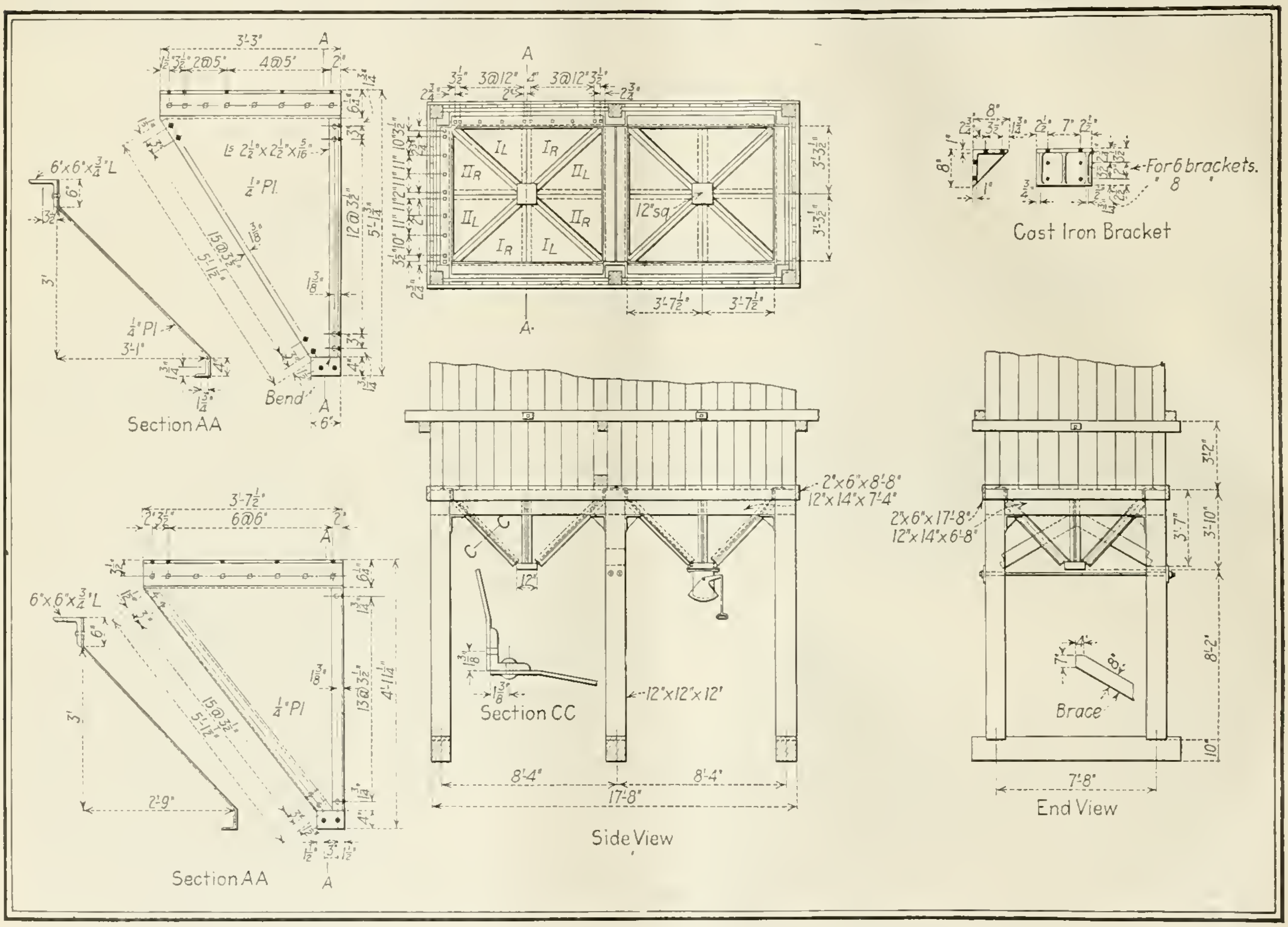
Excavating material includes stripping the deposit and loosening the material. Excavators are built of various types and in several sizes, and ordinarily are supplied with buckets having capacities ranging from ½ to 2½ cu. yd. Daily or hourly capacity of excavators depends upon the span or reach of the machine and general efficiency of operating methods. Clam-shell and orange-peel buckets operated by a derrick are used at some pits. This method of excavating is of limited application because not permitting great output, and is therefore not always most economical. Teams using scrapers, either wheel or drag, can also be operated to strip the deposit.

For plants of large capacity, excavating is perhaps best accomplished by using steam shovels equipped with buckets having a capacity of from 1½ to 2½ cu. yd. These machines excavate the material from the deposit and load into hopper-bottom, or standard-bottom, railway or industrial dump cars, which are hauled by industrial locomotives to receiving hoppers. For small outputs, traction shovels of various types will be found satisfactory. A locomotive crane is also efficient in many cases.

One of the efficient excavators in use today is the drag line type, which can be used for a variety of conditions. For an output not exceeding 500 yards per day it is usually very efficient. Where a deposit cannot be worked out of face then a clam-shell or orange-peel bucket may be used, but as already mentioned, the possible output will be restricted.

Excavated material may be raised to the hopper of the washing and screening plant by any one of several types of elevators and conveyors. Some of the elevators are self-contained in wood frames and are fitted with a plain or geared head. Buckets are attached either to rubber or canvas belts and the speed of travel is low. The continuous bucket elevator requires but little space for installation, is of the slow-speed type and may be adapted to chains, as well as to belts. Belt conveyors are extensively used for delivering material to the head hopper of the screening or washing plant. The conveyor, like the elevator, receives material from a track hopper into which contents of cars have been dumped. The belt extends upward from the track hopper to the head hopper at an angle generally not exceeding 22° with the horizontal. Under the track or tail hopper an automatic feeder is placed.

Three different types of feeders are in use: reciprocating, apron and revolving. Reciprocating feeders deliver material without supervision at a uniform rate, being adjustable to meet the capacity of the conveyor. If a reciprocating feeder will not operate because of the distance the material has to be moved then an apron feeder may be used. The rate of speed is even and the power is uniform. Likewise the revolving feeder is satisfactory because of simplicity of installation and ease of feed regulations. If the material has been elevated to the head hopper the operations of screening and washing (and crushing if necessary) logically follow.



Details of Semi-Portable Gravel Washing and Screening Plant, Capacity 350 cu. yd. Per Day.

Several types of screens offer a choice in equipping a plant such as illustrated. These can be grouped under the classifications of gravity, reciprocating and rotary. The first mentioned is so named because the material rolls down over its face by weight alone, the screen being fixed. Generally speaking the gravity screen is not entirely satisfactory because a deposit may contain material lacking uniformity, and this method will not produce the separation nor cleansing desired.

As regards sizing material, reciprocating or vibrating screens have marked advantages over gravity types. In spite of the fact that they have been used extensively in coal and metal mining plants, their application to the preparation of gravel and sand for concrete construction has been limited. In fixing these screens they are arranged with an attachment that permits changing the operating angle of the surface so as to best meet varying conditions in the material to be handled. Materials to be screened and washed must be distributed evenly across the face of the screen and at a uniform rate, also vibration, or the reciprocating motion, must be greater at the feed end than at the discharge end because of the greater quantity handled.

Rotary screens may be divided into: straight-cylindrical, combined cylindrical-conical (so-called because embodying two principles), and the multiple conical. Cylindrical screens are made by attaching perforated metal or wire cloth to circular metal frames, the openings being such as to produce a product of the desired grading. These screens do not size material very satisfactorily nor do they always accomplish washing in the best degree. In comparing the several types of rotary screens, it is only fair to say that the horizontal-operating conical screens generally produce the best results among those of this type.

To obtain materials properly sized for one-course concrete street and highway pavement which calls for a washed gravel varying from ¼ to 1½ in. and a washed sand grading from ¼ to that which will be retained on a No. 100 mesh screen, perforations in the screen in the majority of cases should be as follows: A 1½-in. diameter for holes in the first conical screen; the same size in the inner skirt or screen; and holes of ⅜-in. diameter in the following screen.

In two-course pavement construction an additional size of material is required, lying either between ¼ and ½ in. in grading or between ¼ and 1 in. To obtain this, the material must pass through a screen having perforations 1 or ½ in. in diameter and be retained on a screen having

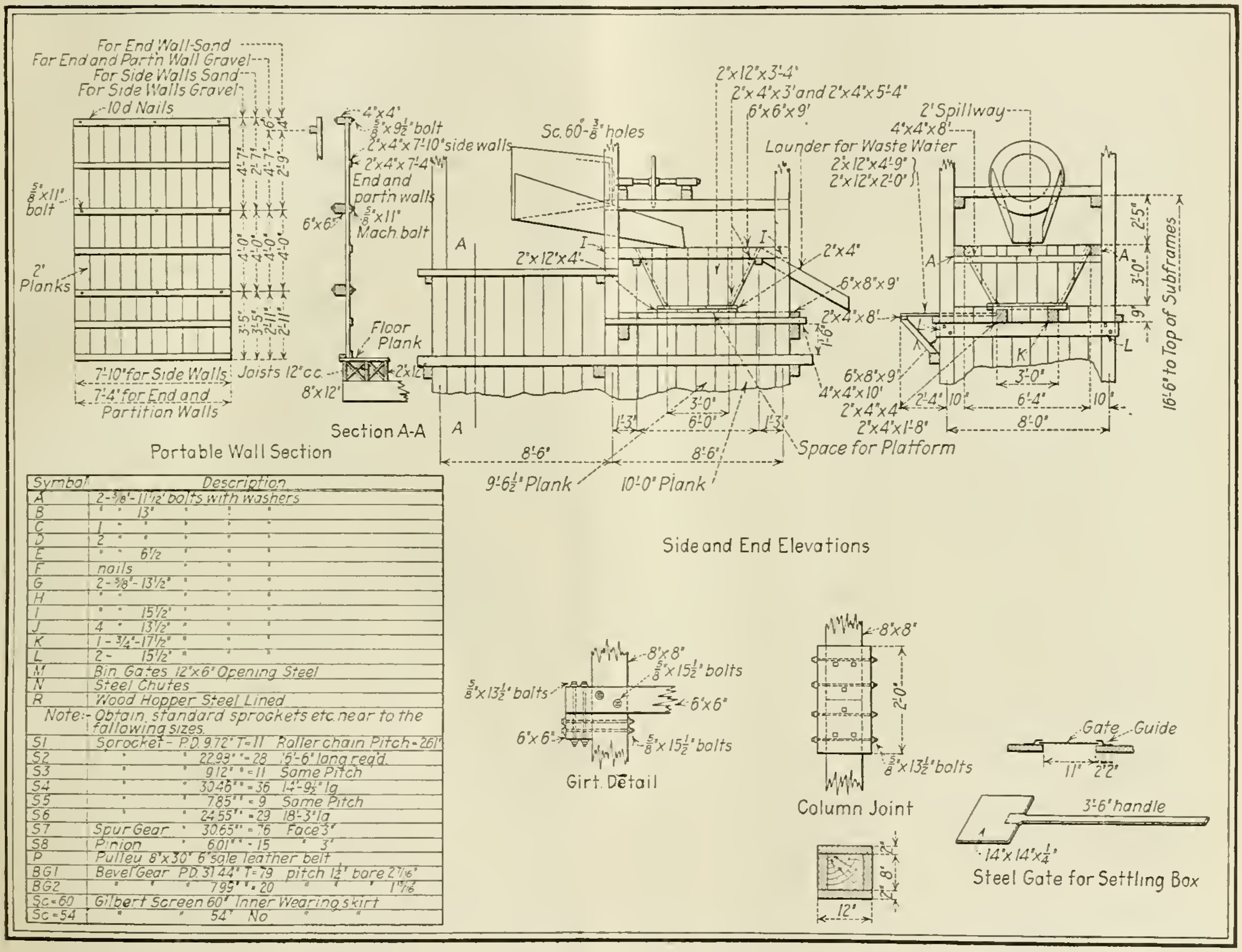
5/16-in. perforations. Unless a very large percentage of the material lies between ¼ and ½ in., or ¼ and 1 in. as it comes from the pit, this intermediate grading cannot be performed in the same operation that produces the material graded from ¼ to 1½ in. Contractors should remember that when specifications refer to material retained on a ¼-in. screen, the screen meant in every case is one of the testing type which is nothing more than ¼-in. wire mesh stretched on a circular rim of small diameter. This testing screen is held horizontal when the material is being tested, and hand-shaken sufficiently to force all material under ¼ in. through the mesh. Therefore, perforations of screens for use in screening and washing plants must be such as will produce a finished product that will pass the hand-screen test. If speed of travel is made great enough, one can appreciate the fact that material which would otherwise pass through a ½-in. mesh can be made to pass over it.

Successful operation of a combined screening and washing plant calls for a sufficient supply of water not only to remove silt, clay and similar foreign materials but to assist in sizing. Every screen should therefore be supplied with a separate water spray which serves to rinse the material as it finally leaves the screen. The quantity of water generally required to wash and size aggregates thoroughly as taken from the pit, varies from ½ to 1 gal. per minute per cubic yard of sand and gravel handled per day. If the output is to 500 cu. yd. per day, the quantity of water required will therefore vary from 250 to 500 gal. per minute at the pump. This apparent wide variation in water requirements anticipates differences in the nature of the sand and gravel encountered.

In determining pump capacity it is necessary to know the quantity of water required, length of pipe between the pump and the point of discharge, the size of pipe, total distance from the surface of the water at the suction end to the point where the water is discharged, and the pressure required at discharge outlets. In determining these factors, some assume a discharge pressure equal to at least 30 lb. per square inch and a pipe varying from 4 to 6 in. in diameter for plants of moderate capacity. The larger pipe reduces friction head and generally proves most economical. Pumps which have proved most efficient are of the centrifugal type.

In many gravel pits large boulders are encountered and in some deposits may form a large portion of the output. Economy suggests that in such cases some suitable type of crusher be a part of the contractor's equipment to utilize all product of the excavator.

The accompanying drawings show elevation of bins, screens and elevating mechanism of a sand and gravel washing and screening plant having an estimated capacity of 350 cu. yd. per day, with bins having a capacity of 22 cu. yd. of gravel and 18 cu. yd. of sand, also details of hopper bottom bins and details of various portions of the construction, together with a bill of material. This bill does not in every case give the exact length of each piece required but shows the number of pieces of standard lengths necessary. Screens, shafts, sprockets, pulleys, etc., can be obtained in the open market and in most cases the design can be adapted to manufacturers' stock equipment. Such special castings as may be necessary can be obtained by submitting designs to a commercial foundry.



| Symbol | Description |
|---|---|
| A | 2-⅝"-11½" bolts with washers |
| B | " " 13" " " " |
| C | 1 " " " " " |
| D | 2 " " " " " |
| E | " " 6½ " " " |
| F | nails " " " |
| G | 2-⅝"-13½" " " " |
| H | " " " " " |
| I | " " 15½" " " " |
| J | 4 " 13½" " " " |
| K | 1-¾"-17½" " " " |
| L | 2- 15½" " " " |
| M | Bin Gates 12"x6" Opening Steel |
| N | Steel Chutes |
| R | Wood Hopper Steel Lined |
| Note:- | Obtain standard sprockets etc. near to the following sizes. |
| S1 | Sprocket - P.D. 9.72" T=11 Roller chain Pitch-2.61" |
| S2 | " " 22.93" " = 28 15'-6" long req'd. |
| S3 | " " 9.12" " = 11 Same Pitch |
| S4 | " " 30.46" " = 36 14'-9½" lg |
| S5 | " " 7.85" " = 9 Same Pitch |
| S6 | " " 24.55" " = 29 18'-3" lg |
| S7 | Spur Gear " 30.65" = 76 Face 3" |
| S8 | Pinion " 6.01" " - 15 " 3" |
| P | Pulley 8"x30" 6" sole leather belt |
| BG1 | Bevel Gear P.D. 31.44" T=79 pitch 1¼" bore 2⁷⁄₁₆" |
| BG2 | " " " 7.99" " = 20 " " " 1¹⁵⁄₁₆" |
| Sc-60 | Gilbert Screen 60" Inner Wearing skirt |
| Sc-54 | " " 54" No " " |

Details of Semi-Portable Gravel Screening and Washing Plant, Gravel 22 cu. yd., Sand 18 cu. yd.

Careful attention to details when laying out material will no doubt suggest short cuts of various kinds that will introduce desirable economies. Construction has been designed so as to produce a plant that would be as nearly portable as possible—entirely portable, of course, when dismantled into the several units of which composed. Bins may be of timber or steel; if properly designed, either type can be made portable.

The method of charging the elevator will depend upon conditions and upon the general construction plant possessed by the contractor. The drawing shows team runways leading to the hopper, but the hopper can also be loaded by any one of the excavating equipments already briefly mentioned.

At the time of laying out the several units or members of the plant or at least when dismantling it for the first time, it would be well to mark each piece of the construction in such a way as to make subsequent erection simple. Assembly can be largely performed by bolts, lag screws and dowels. Timber should be carefully selected for this construction, be straight grained, free from "wind" and any other defects that will cause pieces to warp out of shape or otherwise deteriorate rapidly and thus permit repeated erection and dismantling of equipment with greatest economy of expenditure in time and material.

BILL OF MATERIAL FOR SEMI-PORTABLE GRAVEL PLANT.

MACHINERY.

Machinery—
- 1 32'-0" incl. bucket elevator—50 tons per hour.
- 1 60" Gilbert screen, with inner skirt.
- 1 54" Gilbert screen, no inner skirt
- 1 22'-2 7/16" turned shaft (approx. length).
- 6 fixed post bearings.
- 1 3'-6"x1 15/16" dia. countershaft (approx length).
- 1 4'-0"x2 7/16" dia. countershaft (approx. length).
- 6 sprockets, 1 spur gear and pinion. (See table.) 70'-0" S. B. R. 2.61" pitch drive chain (approx.).
- 1 pulley, 8" face, 50" dia.
- 2 steel screen chutes.
- 1 wood steel lined head hopper chute.
- 1 wood steel lined team hopper.
- 1 8 h.p. gasoline engine.
- 1 centrifugal pump (cap. 300 gal. per minute, disch. pipe 4" dia.) and necessary pipe.
- 1 10 h.p. gasoline engine for pump.
- 4 bin gates—st'd quadrant—12"x16".
- 1 grizzly screen, 1¾" openings (4'-8"x5'-4").

FRAMING.

| No. pcs. | Dimensions. Material. | Bd. ft. |
|---|---|---|
| Sub-frames— | | |
| 18 | 2"x6"x10'-0", yellow pine | 180 |
| 9 | 8"x8"x4'-2", yellow pine | 203 |
| 6 | 8"x8"x4'-6", yellow pine | 144 |
| 2 | 8"x8"x9'-0", yellow pine | 96 |
| 3 | 8"x12"x9'-0", yellow pine | 216 |
| 5 | 8"x12"x10'-0", yellow pine | 400 |
| 60 | ½"x6" dowels, steel | ... |
| 4 | lbs. 20d. nails | ... |
| 12 | ⅝"x13" bolts and washers | ... |
| 16 | ⅝"x11½" bolts and washers | ... |
| BINS. | | |
| Floor— | | |
| 6 | 2"x4"x16'-0", yellow pine | 64 |
| 2 | 2"x4"x12'-0", yellow pine | 16 |
| 5 | 1"x2"x14'-0", yellow pine | 12 |
| 2 | 2"x10"x9'-0", yellow pine | 30 |
| 18 | 2"x12"x10'-0", yellow pine | 360 |
| 10 | 2"x12"x18'-0", yellow pine | 360 |
| 11 | lbs. 10d. nails | ... |
| Side Walls—Gravel— | | |
| 16 | 2"x4"x7'-10", yellow pine | 83 |
| 20 | 2"x10"x12'-0" yellow pine | 400 |
| 9 | lbs. 10d. nails | ... |
| Partition and End Wall—Gravel— | | |
| 14 | 2"x4"x7'-4", yellow pine | 74 |
| 16 | 2"x12"x12'-0", yellow pine | 384 |
| 7 | lbs. 10d. nails | ... |
| End and Side Walls—Sand— | | |
| 8 | 2"x4"x7'-4", yellow pine | 39 |
| 8 | 2"x12"x10'-0", yellow pine | 160 |
| 14 | 2"x4"x7'-10", yellow pine | 74 |
| 20 | 2"x10"x10'-0", yellow pine | 333 |
| 11½ | lbs. 10d. nails | ... |
| Girts and Posts— | | |
| 7 | 4"x4"x16'-0", yellow pine | 93 |
| 6 | 6"x6"x10'-0", yellow pine | 180 |
| 4 | 6"x6"x20'-0", yellow pine | 240 |
| 4 | 8"x8"x14'-0", yellow pine | 300 |
| 2 | 8"x8"x20'-0", yellow pine | 214 |
| 4 | 8"x8"x12'-0", yellow pine | 256 |
| 46 | ⅝"x9½" bolts and washers | ... |
| 68 | ⅝"x11" bolts and washers | ... |
| 116 | ⅝"x13½" bolts and washers | ... |
| 48 | ⅝"x15½" bolts and washers | ... |
| 16 | 3"x4"x½" plate | ... |
| 2 | 1" steel rods, 10'-0" | ... |
| 4 | 1" steel rods, 11'-2" | ... |
| 2 | 1" steel rods, 10'-7" | ... |
| Top Frame— | | |
| 2 | 2"x4"x3'-4", yellow pine | 4 |
| 1 | 2"x6"x12'-0", yellow pine | 12 |
| 2 | 2"x6"x14'-0", yellow pine | 28 |
| 3 | 2"x8"x12'-0", yellow pine | 48 |
| 4 | 4"x6"x9'-0", yellow pine | 72 |
| 2 | 4"x6"x1'-9", yellow pine | 7 |
| 6 | 6"x6"x8'-0", yellow pine | 144 |
| 4 | 6"x6"x9'-0", yellow pine | 108 |
| 1 | 6"x8"x14'-0", yellow pine | 56 |
| 1 | 6"x12"x13'-0", yellow pine | 78 |
| 2 | 8"x10"x9'-0", yellow pine | 120 |
| ⅝" Bolts and Washers— | | |
| 12 | 6½"; 4 11½"; 28 13"; 24 13½"; 4 15½"; 2 ¾"x24". | |
| Settling Tank— | | |
| 6 | 2"x4"x10'-0", yellow pine | 42 |
| 2 | 4"x4"x8'-0", yellow pine | 21 |
| 2 | 6"x6"x9'-0", yellow pine | 54 |
| 4 | 6"x8"x9'-0", yellow pine | 144 |
| 10 | 2"x12"x14'-0", yellow pine | 280 |
| 1 | 2"x12"x16'-0", yellow pine | 32 |
| 1 | lb. 10d. nails | ... |
| Bolts and Washers— | | |
| 6 | ½"x8"; 6 ½"x10"; 8 ⅝"x15½"; 8 ¾"x15½"; 4 ¾"x17½". | |
| Team Hopper— | | |
| 2 | 4"x8"x11'-0", yellow pine | 60 |
| 4 | 8"x8"x2'-0", yellow pine | 43 |
| 4 | 8"x8"x7'-0", yellow pine | 149 |
| 2 | 8"x8"x11'-0", yellow pine | 118 |
| 9 | 2"x8"x12'-0", yellow pine | 144 |
| 2 | lbs. 20d. nails | ... |
| | Total | 6,675 |
| | Estimated cost of plant | $2,000.00 |

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# ORGANIZATION AND OUTPUT OF A GANG LAYING CONCRETE BASE FOR ASPHALT PAVEMENT.

Contributed by W. D. Jones, Assistant Engineer, Harbor Department, Los Angeles, Cal.

In paving a street with 6 in. of concrete, 1 in. of binder, and 2 in. of asphalt wearing surface at Los Angeles Harbor, California, the Fairchilds-Gilmore-Wilton Co. of Los Angeles, contractors for the work, had the following output, plant and organization for one working day of 8 hours with good clear running and no important stops.

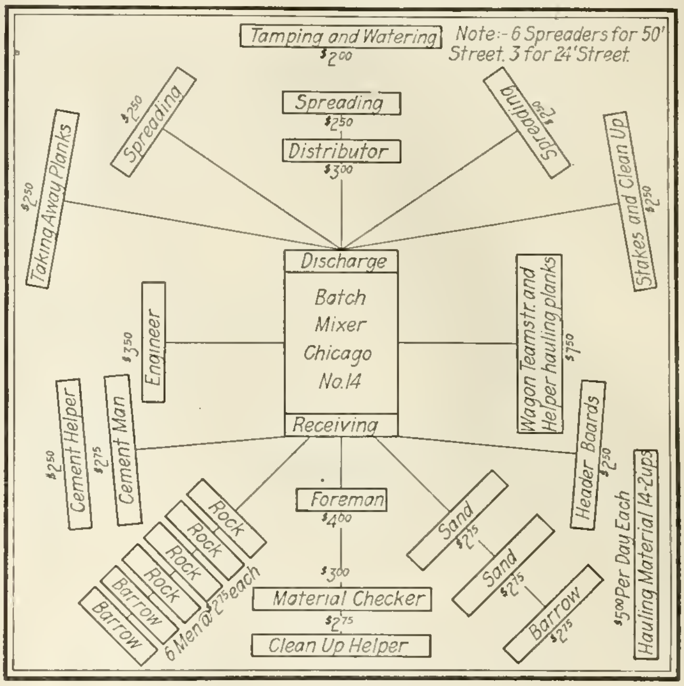

Diagram of Gang Organization.

The mix was 1:3:6 of cement, sand and crushed rock, respectively, and was mixed in batches by a No. 14 Chicago Street Paver having a charging skip and a revolving spout for discharge. The base on which concrete was laid had previously been prepared and stakes driven with tops 2 in. under the sub-grade in order that they might be worked over. Planks 2 in. x 10 in. were laid out ahead and concrete materials, in quantity necessary per foot of street, piled on these for ease in shoveling to wheelbarrows. Cement was piled alongside the street at intervals necessary for handling to the mixer. as the work progressed, by hand. Fourteen wagons hauled the necessary materials from stock piles about ¼ mile away, over dirt road. Occasionally an extra load had to be brought in close to the mixer or one taken away in order to correct up error in gaging the quantity necessary, by wagon loads, but as a rule the measurements checked out pretty well. Two men shoveling into one sand barrow and four men into two rock barrows kept the mixer supplied with sand and rock, the men taking turns at wheeling the barrows up the incline to dump into charging skip. One cement man fed mixer and his helper carried sacks from the storage piles mentioned above to the platform on which he stood. One wagon with body removed, one teamster and two men were kept busy taking out planks after the mixer had passed over and before they were covered with concrete, and hauling them ahead and placing them for additional material as the work progressed.

One man put in and maintained the header boards which limited the edge of the pavement and another was kept busy between grading and cleaning up in the wake of the mixer and in driving stakes to the grade of the finished surface of the street; this was done by measuring up from the tops of stakes previously driven below subgrade, all stakes having been driven the same distance below finished grade. One man attended to the discharging spout and three men to leveling and working the concrete to place 3 in. below the finished surface of the street. Three men took care of this end when the street was 24 ft. wide or narrower but more men were necessary in laying a wider pavement, six being necessary on a 50-ft. street as shown in the picture, Fig. 1, which was taken on a day when the mixer was running a 50-ft. street, or rather the 50-ft. portion of this street, the cost having been observed on a 24-ft. section. One man followed up after concrete was fairly hard and roughened the surface of the concrete with a triangular stamp in order to give a better bond with the binder; he also put up barriers and wet down the concrete. In eight working hours 13,000 sq. ft. of 6-in. base was laid with this mixer and organization. This amounts to 241 cu. yd. for the day and to 1 cu. yd. every 2 minutes. The organization and cost summarized is as follows:

View of Mixer Goirg at Work.

| | |
|---|---|
| 1 foreman at $4 | $ 4.00 |
| 1 engineer at $3.50 | 3.50 |
| 1 checker at $3 | 3.00 |
| 1 cl. helper at $2.25 | 2.25 |
| 14 teams and drivers at $5 | 70.00 |
| 6 rock men at $2.75 | 16.50 |
| 3 sand men at $2.75 | 8.25 |
| 1 cement man at $2.75 | 2.75 |
| 1 cement helper at $2.50 | 2.50 |
| 1 header, boards, at $2.50 | 2.50 |
| 1 team, driver and helper at $7.50 | 7.50 |
| 1 plank man at $2.50 | 2.50 |
| 1 stake man at $2.50 | 2.50 |
| 1 spout man at $2.50 | 2.50 |
| 3 leveling at $2.50 | 7.50 |
| 1 tamp and water at $2.00 | 2.00 |
| Total labor | $139.75 |
| 241 cu. yd. ....Per cu. yd. | 0.58 |
| Total labor exclusive of hauling material to site | 69.75 |
| Total labor exclusive of hauling material to site....Per cu. yd. | 0.29 |

The diagram, Fig. 2, shows distribution of organization about the mixer.

## THE CLAYTON COUNTY, IOWA, PATROL SYSTEM FOR MAINTENANCE OF DIRT ROADS.

An excellent patrol system of dirt road maintenance has been in operation in Clayton County, Iowa, for the past two years. Under this system the county in 1915 paid nearly 21 per cent per mile less for dragging of its roads than the average county in the state In addition the roads are fully 50 per cent better than they were 3 years ago. The system was inaugurated by Mr. Edward B. Tourtellot, county engineer, and is described by him in the May-June Service Bulletin of the Iowa Highway Commission. The following is taken from the Service Bulletin:

The patrol system covers the entire 226 miles of county road, the average length of each patrol being about 10 miles. This length is to be reduced this season to about 7 miles in parts of the county as it is believed the cost will be decreased by so doing. Less time will be consumed in going and coming to and from work, which will more than offset the additional wage paid to the patrolman.

The selection of the patrolman is with the supervisors, each supervisor attending to the covering of the road in his district. Men of experience in road work and capable of handling a gang, if necessary, are the type selected as a rule, although it is sometimes difficult to get the right man. No intemperance is allowed.

The patrolman is under a written contract to work for the county at the time and place designated by the board of supervisors or the engineer. In the past the patrolman was required to give a bond to insure the care and return of tools. This year this requirement has been struck out as it was considered unnecessary. The average price paid to patrolmen throughout the county is 27½ cts. per man, 47½ cts. per man and team and 10 cts. per each extra horse per hour. Extra help is paid 25 cts. per man and 45 cts. per man and team per hour. The patrolman is authorized to hire help for dragging. All road tools are supplied by the county and the understanding is that the patrolman will take reasonable care of these. At the close of the season an inventory of all tools, supplies and road material is made and sent to the engineer.

The primary object of the patrol system is to keep the road in passable condition. In addition to maintenance, the patrolman has charge of any permanent work, outside of blade grader work, which is done on his patrol. If advisable, one or more patrolmen are called to the assistance of another on any work of considerable size, the patrolman of that district assuming charge of the work. In no case is dragging or emergency repair neglected for this work. The patrolman is also used for bridge repair work on township roads in the vicinity of his patrol. For counties doing day labor work on culvert or bridge construction he will be a valuable asset. Not all of the patrolmen depend on road work for a living, although several were employed who were kept at work throughout the season. A number of the patrolmen own or rent small tracts of land, and when not employed in county work, are able to attend to their own interests. They are, however, under obligation to work for the county at any time the board of supervisors or engineer demand their services.

All maintenance work on the patrol system is under the inspection of the supervisors or the engineer. At the beginning of the season a trip is usually made by the supervisor of that district or by the enginer, in company with the patrolman, and the work of the season outlined. All permanent work is staked by the engineer, who superintends the construction.

Weekly time sheets are used for keeping the patrolman's time. Separate sheets are required for each man for each week. At the end of the week the patrolman sums up his time and transfers it, as a total for the week, to his claim. He then sends the time sheet to the engineer, who checks it and if any mistake is found, returns it for correction. In this way any correction can be made before the board meets. Claim sheets are filled at the end of the month and the time shown must check with the time sheets. All time sheets are retained in the engineer's office. On the time sheets a space is reserved for quantities of work done. In this way an accurate record of the cost of the work is kept, and a comparison with other patrols can readily be made. Special unit cost sheets are used by the engineer for this purpose. Requisition books are supplied each patrolman, and no claim is allowed the dealer unless a duplicate requisition is attached. When the patrolman pays cash for the supplies or tools, a receipt from the dealer must be attached to his claim.

The total cost of dragging for 1915 was $5,321. The total miles regularly dragged were 225, and the average number of times dragged was 42. This gives the total number of miles dragged for the season as 9,450 or an average cost of 56½ cts. per mile per round trip compared with the average cost of 71.3 cts. per mile per round trip for all the counties of the state. The dragging in most of the counties of the state was let by contract. This means a saving of 14.8 cents per mile per round trip, or multiplying this by 9,450, gives a saving effected by Clayton county of $1,400. This saving is, without question, due to the patrol system as shown below.

The average rate paid throughout the state per hour for a man and team during the past season was 47½ cts., the same as paid for patrolmen (this rate is based on figures obtained from engineers of various counties in the state). The time required to drag one mile of road per round trip, is found from actual experience to be about one hour. The average number of horses used on each drag last season was three, which means a cost of 47½ cts. plus 10 cts. or 57½ cts. per mile per round trip. This checks within a cent with the average cost shown above. If a mile can be double dragged in one hour with three horses in Clayton county it surely can be done in any other county in the state, where the average rate is shown to be 71.3 cts. In other words the average county in the state is paying the price of 1¼ miles for the dragging of one mile of road.

From the cost sheets kept in the engineer's office the following unit costs for permanent work were compiled:

| Material. | Quantity. | Rate. | Amount. |
|---|---|---|---|
| Dirt | 30,600 cu. yd. | 15½ ct. | $4 745.00 |
| Rock | 1,520 cu. yd. | 33½ ct. | 510.00 |
| Placing and hauling corrugated culverts | 3,018 feet | 27½ ct. | 830.00 |

The average cost per mile per year of the maintenance was $113.

## SAND ASPHALT ROAD CONSTRUCTION IN DE SOTO COUNTY, FLORIDA.

In many sections of Florida sand is about the only material locally available for road construction purposes. Various attempts have been made to combine this sand with asphalt and a number of successful pavements of this kind have resulted. In some of the work, however, the sand has been used as it was found along the road regardless of grading. This practice, of course, has not tended to improve the quality of the mixture.

The 5th Road and Bridge District of De Sota County proposes the construction of a large amount of sand asphalt pavement. Bids calling for approximately 561,000 sq. yd. of this surfacing were opened on July 3. On this work precautions have been taken to secure a proper grading of the sand. Samples of the available sand were taken from along the roads to be improved. These samples were screened and a list prepared giving the grading. This list showing the sand grading over the district was a great convenience to prospective bidders, for it enabled them to determine the amount they would have to import and it also aided them in arriving at the best location for the plant.

The pavement is to be 2 in. thick after compression and laid on a 6-in. clay base with shoulders on each side 2 ft. wide. The width of the pavement is to be not less than 9 ft. nor more than 16 ft.

The specifications for the 5th Road and Bridge District roads provide that the sand shall be clean, sharp and free from loam, clay or other deleterious material. It must be tested and graded for size, from fine to coarse, so that the fine sand will as nearly as possible fill the voids in the coarse sand. If necessary two or three different sands must be mixed to secure the proper grading. The composition of the surface mixture must not vary beyond the following limit:

| | Per cent. |
|---|---|
| Bitumen | 7 to 12 |
| Passing 200-mesh sieve | 6 to 12 |
| Passing 100-mesh sieve | 9 to 20 |
| Passing 80-mesh sieve | 9 to 20 |
| Passing 50-mesh sieve | 10 to 35 |
| Passing 40-mesh sieve | 10 to 25 |
| Passing 30-mesh sieve | 6 to 15 |
| Passing 20-mesh sieve | 4 to 10 |
| Passing 10-mesh sieve | 2 to 8 |

The asphalt cement must conform to the following requirements:

(1) It must be thoroughly homogeneous, and the various ingredients contained in it shall be in a state of complete solution.

(2) It shall have a penetration of between 40 and 75 at 77° F., depending on the sand and asphalt used and the traffic upon the roads upon which the pavement is to be laid.

(3) It shall not flash below 350° F. when tested in a New York State closed oil tester.

(4) When heated in an open tin at a temperature of 325° F. for five hours in a hot air oven, it must not show a loss of volatilization of over 5 per cent and the penetration at 77° F. of the residue left after such heating must not be less than one-half the penetration of the original sample before heating.

(5) When the pure bitumen of the asphalt cement is brought to a penetration at 77° F. of 50 and made into a briquette having a cross section of 1 sq. cm., it shall have a ductility of not less than 20 cms., at 77° F., the two ends of the briquette to be pulled apart at the uniform rate of 5 cm. per minute.

When the asphalt cement as used has a penetration greater than 50 at 77° F., an increased ductility of 2 cm. shall be required for every five points in penetration above 50 penetration.

The amount of asphalt cement to be used will be governed by the sand grading, but must be sufficient to thoroughly cover the surface of all particles of mineral aggregate employed, without leaving an excess of bitumen. The contractor will be paid at his unit price bid according to the variation of bitumen between

7 and 8 per cent
8 and 9 per cent
9 and 10 per cent
10 and 11 per cent
11 and 12 per cent

The filler will be thoroughly dry limestone dust or other mineral matter of sufficient density to produce a powder having a density of at least 90 lb. to the cubic foot. It must be so finely ground that all of it shall pass through a 50-mesh screen and at least 66 per cent of it shall pass through a 200-mesh screen. The surface mixture must contain from 6 to 20 per cent of this filler, depending upon the kind of sand and asphalt used.

The mineral aggregate and asphalt cement will be heated and mixed in a standard asphalt plant. The mineral aggregate will be heated to a temperature of from 250 to 350° and then incorporated into the cement heated to approximately the same temperature. The mixture must arrive at the road at a temperature of not less than 200° F. It will be deposited upon sheet iron platforms and then carried to position with hot shovels and shaped with hot rakes. Rolling will be done with a self-propelled tandem of not less than 6 tons' weight. After the final rolling the finished surface will be covered with the best quality of Portland cement and swept evenly into the pavement with soft hair brooms. The edges of the wearing surface will be protected by placing shoulders of the same material as the foundation for a width of 2 ft. on either side and rolling until they conform to the cross section. The shoulders will have a finished thickness of 6 in.

Phil Lacey, Zolfo, Fla., is Engineer Fifth Road and Bridge District, and D. L. Skipper is Commissioner.

## GRADING ROADS PREPARATORY TO HARD SURFACING.

Contributed by Neal B. Garver, Associate in Civil Engineering, University of Illinois, Urbana, Ill.

Where hard surface roads are being constructed it is the common practice to let both the grading and surfacing under one contract, and it is expected that the entire contract will be completed in one season. This method has some serious faults. It is only necessary to travel over some of the roads recently constructed to see what these faults are.

While traveling over several miles of concrete road recently the following conditions were found to exist: At one point there was a concrete girder bridge with a 4 or 5-ft. earth embankment at either end. The embankment had settled, but the bridge had not. The result was a badly broken pavement at each end of the bridge.

At another point a trench had been dug across the roadway and a concrete culvert built. After the hard surface had been constructed the backfill had settled. The result was the same as in the first case.

W. E. Emery, County Superintendent of Highways of Peoria County, Illinois, is using a method of meeting this problem which seems worth while. He has secured the consent of the State Highway Department to have the grading and surfacing contracts let separately. The roadway is brought to the permanent grade one year, and the hard surface is constructed the next. For example, the roads which are to be hard surfaced this year were graded last fall and are now in good condition. There is enough money now left in the road fund for this year to do the grading on the road to be hard surfaced next year.

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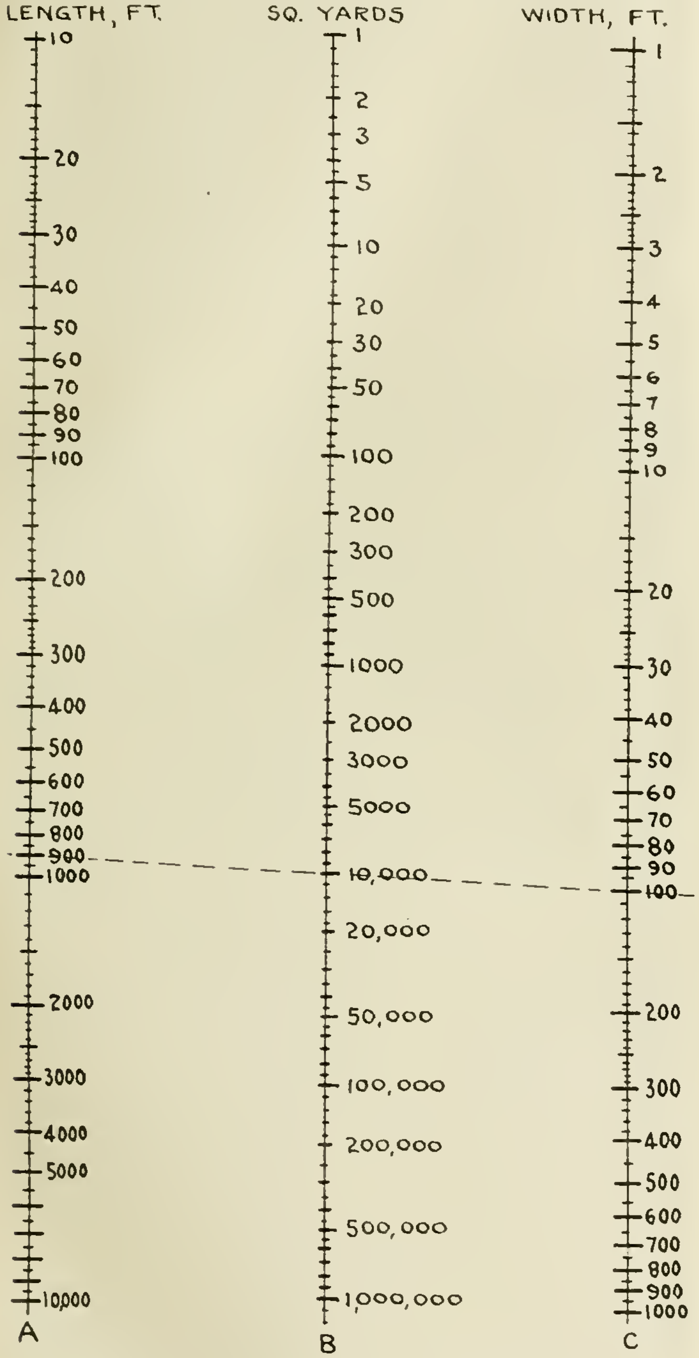
## A HANDY ROAD CHART.

Contributed by N. G. Near, New York City.

The accompanying chart will be of service to road builders for determining the number of square yards in any road up to nearly 2 miles in length and in any width up to 1,000 ft. Just lay a straightedge across as indicated by the dotted line and the area is immediately found in the middle column (column B).



For example: A certain contractor laid 900 ft. of road in one day, the width of the road being 100 ft. Connect the 900 (column A) with the 100 (column C) and column B gives the area as 10,000 sq. yds.

The chart is especially valuable for estimating work, for the foreman in making his daily report, or for anybody who has to do figuring of this kind.

## A NEW FORM OF SPECIFICATIONS FOR CONCRETE AGGREGATES.*

To be generally acceptable specifications for concrete aggregates should fulfill two requirements, namely: (1) they should insure the production of suitable concrete if the aggregates are properly used; and (2), they should permit the use of materials found in the vicinity of the work, if such materials are capable of producing concrete of the required quality.

The present method of specifying may insure the quality of the material, but it does not permit the use of a wide choice of aggregates from which first-class concrete may be made.

It is quite possible to write specifications for sand and stone which will answer the purpose in New York, others for Pittsburgh, and still others for New Orleans, but they will all differ from each other if they are to be met by the local products.

Concrete is a cheap building material because it is composed largely of inexpensive aggregates, and for economic reasons these aggregates should be secured from deposits in the vicinity of the point of use. Whatever materials are locally available for aggregates must be used in the great majority of cases, for aggregates which must be transported long distances are no longer inexpensive. The material at hand capable of making concrete of fair quality will generally be used in preference to a better material which must be brought from a distance at considerable cost for transportation.

It is generally true that even a very poor sand; that is, one which compares very unfavorably with standard Ottawa sand when tested in 1:3 mixtures with cement, will give a suitable compressive strength if sufficient cement is used. Take, for example, a fine, poorly graded sand, which in a 1:3 mortar gives a compressive strength equal to only 60 per cent of that obtained with standard Ottawa sand. Such a sand used in the proportion of 1:2 or 1:2¼ will usually give strengths fully equal to the 1:3 mortar made of Ottawa sand. When the only available sand is of such a quality, it is necessary to increase the proportion of cement until the required strength is obtained.

Our present specifications for sand require that it shall, when tested as prescribed, show a compressive strength approximately equal to that obtained with standard Ottawa sand. A rigid adherence to these specifications would mean that in many sections of the country no concrete work could be done without importing aggregates from a distance. The result is that the specifications are ignored in those localities and the work done without them.

On the other hand, where most excellent materials are available, the present specifications for sand do not permit of a variation of the proportions used no matter how good the materials may be. For instance, some well-graded sands show strengths 40 per cent higher than that obtained with Ottawa sand in 1:3 mortar, and in 1:3½ or even 1:4 mortar show compressive strengths equal to that obtained with Ottawa sand in the proportion of 1:3. Yet this sand receives no credit for quality under the present form of specifications.

Specifications serve their purpose when they secure the products described, but they serve the industry best when broad enough in scope to cover all the materials capable of producing a product of the desired quality. To insist that throughout this country no sand may be used in concrete which does not show a compressive strength approximately equal to that of a standard sand when tested in 1:3 mortar, is in a way analagous to insisting that all structural steel shall be made from an ore containing a certain minimum percentage of iron.

In order to cover and include all materials which are capable of producing concrete of the quality required for the particular service it is to perform it is only necessary to specify the result required instead of specifying the materials used.

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*Paper read by Cloyd M. Chapman before the American Society for Testing Materials.

Let it be assumed, for instance, that for mass foundations and footings, for retaining walls and abutments, and for similar service, a concrete which has a compressive strength of 1,500 lb. per square inch at the age of 28 days is suitable. For reinforced walls and matts where stresses are moderate, a compressive strength of 2,000 lb. per square inch at 28 days may be required, while for reinforced floor slabs, beams, girders, columns, etc., a minimum compressive strength of 2,500 lb. per square inch at the same age may be necessary.

By specifying the results required and permitting the use of such materials as will produce these results when tested under specified and standardized conditions, it is possible not only to properly safeguard the product but to permit the use of such materials as are available in each locality.

It is also true that in many cases the local materials are of such poor quality and would require such a large proportion of cement to fulfill the specifications, that it would be economical to bring in better material even from a considerable distance, the saving in cement paying the freight. Specifications of this kind might take some such form as the following, in which all figures are purely arbitrary and in no sense proposed as standard:

> The materials used shall be of such quality, and shall be used in such proportions as to produce a concrete which shall show a compressive strength of 2,500 (or 2,000 or 1,500) lb. per square inch at the age of 28 days, when tested in accordance with the standard methods of testing

This form of specification is obviously susceptible to modification to cover varying conditions and qualities. For instance, to insure against a material which sets or hardens slowly, and consequently requires forms being kept in place an unusual length of time, the specifications may require a certain minimum strength to be attained in three days. When compressive strength is not the prime requisite, as for instance, in sea wall or tunnel work, the requirements as to impermeability or density may be inserted, either in place of, or in addition to, the strength requirement.

It would probably be desirable to add some further qualifying clauses to the specifications, such as the limit of size of particles, the character of the materials composing the aggregates, freedom from constituents liable to cause deterioration, etc.

The standard methods of testing referred to in these specifications would have to be very carefully worked out, as the value of the specifications is largely dependent upon the reliability of the test, just as is the case in almost all specifications of a like nature which are dependent upon tests.

The method at present most commonly employed, except in the case of some of the railroads and on government work where aggregates, particularly the sand, are systematically tested, is to practically ignore the quality of materials, except the cement, and to arbitrarily specify proportions that will give good enough results with almost any aggregates. By requiring that all concrete in a reinforced structure shall be made in the proportions of say, 1:1½:3 or 1:2:4, we are simply "playing safe." Mixed in these proportions all but the poorest material will produce good concrete. Instead of specifying that "the materials shall be of such quality and shall be used in such proportions as will produce a compressive strength of," etc., we now say, in effect, "the materials may be of any quality, but must be used in the proportions of approximately 1:2:4, so that even poor materials will possibly produce concrete sufficiently good for the purpose." They, in principle, are the specifications under which thousands of yards of concrete are laid every year.

Wherein lies the incentive to a contractor or builder to use any better materials than the cheapest, if he is compelled by the specifications to use a certain arbitrary mix regardless of quality or material?

Any specifications for concrete aggregates which are to be used all over this country, must be so drawn that any material which will make concrete of the required quality will be included. The establishment of a standard of quality and insistence that only materials which measure up to that standard may be used, is bound to be ignored in localities where materials of the quality demanded are not to be found, or else the standard of quality would have to be put much lower than at present—so low as to include the poor material.

In operating under such specifications, it is of great importance that specimens of the concrete produced on the job be regularly made and tested. It is also of the greatest importance that a close day-to-day check be maintained on the quality of the materials used, so as to insure a reasonable uniformity, and to know that these materials are at least equal in quality to the materials used in arriving at the proportions required to give the quality of concrete called for in the specifications.

When the materials used on the job are from the same sources as those tested and from which tests the proportions to be used were determined, it is a simple matter to check up their qualities. Sand and stone from the same source do not vary much in quality, except in so far as quality is influenced by size of particles. Having once established by test the suitability of sand and stone for any grade of concrete and having determined the proper proportions in which to use them to attain a certain desired result, it is only necessary thereafter to see that the size, grading and proportions of these materials are reasonably constant to insure uniform quality of concrete. Such a check on size and grading should be had on each and every shipment of material and is easily obtained with a small set of sieves, or in the case of sand, which is by far the more important material, by means of a self-contained sand tester.

The regular and systematic testing of the size of the aggregates gives data which will permit the engineer to tell without further tests, whether the aggregates will produce a better or poorer concrete than that produced by the original or standard sample. This fact is based on the well-established principle that, other things being equal, the aggregate whose granulometric-analysis curve most nearly approaches the line of maximum density will produce the best concrete. This makes it possible to determine with reasonable certainty which of two sands of the same kind and from the same source, but differing only in fineness, will make the better concrete. These principles are carried out in practice by Westinghouse, Church, Kerr & Co. in the following manner:

Concrete is to be placed in a certain locality. There are to be heavy machinery foundations and thick building foundation walls and footings below grade, with reinforced superstructure. The engineer in charge secures samples of the available concrete aggregates, both fine and coarse, and sends them to the laboratory for test. The tests show that although the best available sand has a strength in 1:3 mortar only 70 per cent of that of standard Ottawa sand, yet mixed in the proportions of 1:1¾:3¾ with the cement and coarse aggregates to be used, the resulting concrete has a compressive strength of 2,600 lb. per square inch at 28 days. Other proportions give higher and lower strengths, depending on their richness, but as the design of the structure requires concrete having a compressive strength of 2,500 lb. per square inch the 1:1¾:3¾ proportion is used. For the foundations and footings, the designs being based on a compressive strength of 1,500 lb. per square inch in the concrete, the proportion of 1:2¼:4½, which gave in the test a compressive strength of 1,550 lb. per square inch, is chosen. Under the present standard method of specifying sand, this particular sand could not have been used in concrete.

Among the tests made in the laboratory on the sand are several granulometric-analysis charts made with the sand tester. This sand tester has five screens having 6, 10, 20, 35 and 65 meshes per inch. Each screen in succession has openings one-half the width of the openings in the preceding screen. The charts are averaged and a special guide chart is prepared for the use of the inspector on the job. In making up this guide chart a permissible variation of about 2.5 per cent each way from the mean of the tests made on the sample, is allowed. A copy of this chart is sent to the job and a copy kept in the laboratory.

As the sand arrives on the job the inspector, or some one designated by the superintendent, makes tests with the sand tester and compares the resulting chart with the guide chart. If the results show greater variation than is permissible—particularly if they show the sand to be finer than shown on the guide chart—then the matter is taken up with the one who supplies the sand. A duplicate chart of all field tests is sent to the engineer.

By this method the quality of the aggregates is recognized and provided for in the selection of proportions for the concrete, and enough cement is used to produce the desired quality. All the materials entering into the concrete are used in the tests and the results are influenced by each of the ingredients. In this way the uncertainty which is attendant upon separately testing each of the three materials, and predicting therefrom the quality of the concrete resulting from their combination, is eliminated. The time required for testing the combination is no greater than that required for testing any one of the materials.

Experience with this form of specification has shown it to be advantageous in localities where the available aggregates are not up to the standards now specified.

## EXPERIMENTAL CONVICT ROAD CAMP NEAR ATLANTA, GA.

An interesting experiment in the use of convicts for road work is being conducted under the immediate direction of J. E. Pennybacker, chief of road economics in the U. S. Office of Public Roads. This honor camp is situated not a great distance from Atlanta, Ga., and has been in operation for about five months. The plant—quarters for the convicts, offices for supervisor and clerk and other necessary buildings—involved an initial expenditure of about $2,000. The supervisor and clerk are employes of the state of Georgia. The convicts, 40 or 50 in number, were selected from various convict camps in the state and are serving sentences varying from 6 months to a year. The most, if not all of these convicts, are from Atlanta. Several of the convicts sent to this camp have been returned to their former places for fighting among themselves or for other breaches of good conduct, but with these few exceptions they have been orderly and industrious. There have been no attempts to escape. During the five months the convicts excavated 25,000 tons of earth and about 20,000 tons of stone, built a concrete bridge and completed an earth road of superior quality 2 miles in length.

The convict quarters were designed with a fine regard to the health of the inmates, with the remarkable result that among the convicts there has been less than one-fourth of 1 per cent of sickness since the camp was established. The cost of feeding the convicts has been 17 cts. per day for three meals. The cost of maintaining the camp, allowing 10 per cent for annual depreciation in the plant, the salaries of supervisor and clerk, cost of transportation of supplies and all other incidental expenses, and cost of feeding and caring for the convicts—is a small fraction over 44 cts. per day per convict.

## METHOD OF PATCHING BITUMINOUS ROADS.

The following method of patching bituminous roads is employed by the patrolmen on the state road system of Maryland: The hole is swept thoroughly clean, and free from all dirt and dust. The cavity is then painted with bituminous material, and the filling stone well tamped in with a tamper. Bituminous material is next spread over the stone and covered with stone chips from ½ in. to ¾ in. in size, just bringing the surface of the patch up to the elevation of the adjoining road surface. To assure getting the proper amount of bituminous material in the patch, the patrolman is supplied with a small wire basket holding about ¼ peck of stone. This basket has handles and when filled with stone is dipped in the bituminous material. The basket is then raised and the excess material allowed to drain off.

## A METHOD OF FIGURING VERTICAL CURVES ADAPTED TO MUNICIPAL PRACTICE.

Contributed by Carl F. Meyer, Morgan Park, Duluth, Minn.

The writer has read with interest the contribution of Mr. Jordan in the issue of Engineering and Contracting under date of June 7, 1916, and submits to your readers as a result his method of figuring vertical curves. Rules and methods for this work have generally been based on railroad engineering practice and the writer has tried to adapt these methods to municipal practice where the rate of change in the curves is much greater and it is desired to get elevations on the curve at frequent intervals, especially in setting grade for curbs. The method sought was also one that would be self-checking; that is, the elevation of each point being computed from the preceding point. The writer has adapted other methods to these conditions and derived the following process:

Let L be the length of the vertical curve.

Let X be the distance between points at which elevations are desired or the chord length.

Let N equal the number of chords, equals L divided by X.

Let G′ equal the difference in elevation in feet for the distance X on the first grade, G′ being plus for a rising grade and minus for a falling grade.

Let G″ equal the same quantity for the second grade. Then

Let A equal a factor equal $\dfrac{G' - G''}{2N.}$

With the above values the following rule may be stated:

To find the elevation of a point on the curve a distance X from the end algebraically add to the elevation of the end station the quantity G′ reduced by the quantity A. To find the elevation of any succeeding point a distance X from the last point, algebraically add to the elevation of the last point the last addative decreased by the quantity 2A. To illustrate:

A grade rises at 0.4 per cent and intersects one falling at 0.6 per cent, compute the elevations of points 25 ft. apart for a curve 200 ft. long.

L equals 200; N equals 8; G′ equals +0.10; G″ equals —00.15; A equals $\dfrac{+0.10 - (-0.15)}{2x8}$ equals +0 015625; 2A equals +0.03125.

COMPUTATIONS.

| Station. | Elevation. | Addative. | G′. | A. | 2A. |
|---|---|---|---|---|---|
| 1+00 | 100.000 | | +0.10 | +0.915625 | |
| 1+25 | 100.084375 | +0.084375 | | | +0.03125 |
| 1+50 | 100.137500 | +0.053125 | | | |
| 1+75 | 100.159375 | +0.021875 | | | |
| 2+00 | 100.150000 | —0.009375 | | | |
| 2+25 | 100.109375 | —0.030625 | | | |
| 2+50 | 100.037500 | —0.071875 | | | |
| 2+75 | 99.934375 | —0.103125 | | | |
| 3+00 | 99.800000 | —0,134375 | | | |

Check—

| | |
|---|---|
| station 1+00 elevation | 100.00 |
| 100 ft. at +0.4% | +0.40 |
| Elevation apex | 100.40 |
| 100 ft. at —0.6% | —0.60 |
| Station 3+00 | 99.80 |

Note that the last addative is equal to G″ decreased by A.

When it is desired to find the elevations on the curve at points which are equal distance from each other, but where the stations of the ends of curves are not even stations or an even multiple of the quantity X the rule can be applied by first computing the elevation of the first point any distance from the beginning of the curve. This computation to be made by the use of the parabolic formula. After finding the elevation of this point assume the vertical curve as starting at the point at which the elevations have been determined and compute the balance of the curve by the method above given.

## REVISED STANDARD TEST FOR PENETRATION OF BITUMINOUS MATERIAL.

A proposed revised standard test for the penetration of bituminous material was submitted at the recent annual meeting of the American Society for Testing Materials by the Committee on Road Materials, of which L. W. Page is chairman and Prevost Hubbard, secretary. The test is designed to supersede the present standard test. The committee recommended that the standard be referred to letter ballot of the society for adoption. This proposed revised standard test was as follows:

**Definition.**—Penetration is defined as the consistency of a bituminous material, expressed as the distance that a standard needle vertically penetrates a sample of material under known conditions of loading, time and temperature. Where the conditions of test are not specifically mentioned, the load, time and temperature are understood to be 100 g., 5 seconds, 25° C. (77° F.), respectively, and the units of penetration to indicate hundredths of a centimeter.

**Apparatus.**—The container for holding the material to be tested shall be a flat-bottom, cylindrical dish, 55 mm. (2 3/16 in.) in diameter and 35 mm. (1⅜ in.) deep.[1]

The needle[2] for this test shall be of cylindrical steel rod 50.8 mm. (2 in.) long and having a diameter of 1.016 mm. (0.04 in.) and turned on one end to a sharp point having a taper of 6.35 mm. (¼ in.).

The water bath shall be maintained at a temperature not varying more than 0.1° C. from 25° C. (77° F.). The volume of water shall be not less than 10 liters and the sample shall be immersed to a depth of not less than 10 cm. (4 in.) and shall be supported on a perforated shelf not less than 5 cm. (2 in.) from the bottom of the bath.

Any apparatus which will allow the needle to penetrate without appreciable friction, and which is accurately calibrated to yield results in accordance with the definition of penetration, will be acceptable.

The transfer dish for container shall be a small dish or tray of such capacity as will insure complete immersion of the container during the test. It shall be provided with some means which will insure a firm bearing and prevent rocking of the container.

**Preparation of Sample.**—The sample shall be completely melted at the lowest possible temperature and stirred thoroughly until it is homogeneous and free from air bubbles. It shall then be poured into the sample container to a depth of not less than 15 mm. (⅝ in.). The sample shall be protected from dust and allowed to cool in an atmosphere not lower than 18° C. (65° F.) for one hour. It shall then be placed in the water bath along with the transfer dish and allowed to remain one hour.

**Testing.**—In making the test the sample shall be placed in the transfer dish filled with water from the water bath of sufficient depth to completely cover the container. The transfer dish containing the sample shall then be placed upon the stand of the penetration machine. The needle, loaded with specified weight, shall be adjusted to make contact with the surface of the sample. This may be accomplished by making contact of the actual needle point with its image reflected by the surface of the sample from a properly placed source of light. Either the reading of the dial shall then be noted or the needle brought to zero. The needle is then released for the specified period of time, after which the penetration machine is adjusted to measure the distance penetrated.

At least three tests shall be made at points on the surface of the sample not less than 1 cm. (⅜ in.) from the side of the container and not less than 1 cm. (⅜ in.) apart. After each test the sample and transfer dish shall be returned to the water bath and the needle shall be carefully wiped toward its point with a clean, dry cloth to remove all adhering bitumen. The reported penetration shall be the average of at least three tests whose values shall not differ more than four points between maximum and minimum.

When desirable to vary the temperature, time and weight, and, in order to provide for a uniform method of reporting results when variations are made, the samples shall be melted and cooled in air as above directed. They shall then be immersed in water or brine, as the case may require, for one hour at the temperature desired. The following combinations are suggested:

At 0° C. (32° F.) 200-g. weight, 60 seconds
At 46°.1 C. (115° F.) 50-g. weight, 5 seconds.

## PERSONALS.

W. M. Atkinson has resigned his position as city manager of Roswell, N. M.

Chester A. Brown has been elected manager of the new city of Sherrill, N. Y.

T. Ed. Bryan and L. P. Dickie have been re-elected president and secretary, respectively, of the Central Florida Highway Association.

Joseph A. Murray, Jr., and Conrad Hamman have been promoted from the positions of levelers to that of assistant engineers, Department of Engineering of Albany, N. Y.

Walter S. Merrill, for the past two years an instructor in civil engineering at Rhode Island State College, has accepted a position with Westinghouse, Kerr & Co., Consulting Engineers, New York City.

Captain Clarence D. Sturdevant, Corps Engineers of U. S. A., in charge of the Pittsburgh District, has been assigned to Montgomery, Ala., to relieve Major Frank C. Boggs, engineer of the engineer department of that district, temporarily.

Richard K. Meade, Chemical, Mechanical and Industrial Engineer, owing to the expansion of his practice and the need for increased facilities, has removed his offices from 202 North Calvert St. to the Law Bldg., Courtland St., Baltimore, Md.

Robert R. Huntley, Augustus Dergenger and Fritz Fernow have organized the Huntley & Dergenger Corporation and will engage in a general construction business, specializing in the construction of railroads, tunnels, etc. The headquarters will be at Buffalo, N. Y.

Lieut.-Col. Wm. V. Judson, U. S. Corps of Engineers, now on duty in the Chicago District, has been ordered to the Baltimore District in the Eastern Division. He will relieve Lieut.-Col. C. A. F. Flagler, who will temporarily relieve Col. John Biddle, who goes to West Point as commandant.

R. M. Hosea, formerly Chief Engineer of the Colorado Fuel & Iron Co., with offices at Pueblo, Colo., is at present engaged on valuations of coal mining properties for companies and individuals. He also is engaged in a general consulting practice, with offices at 1062 Pearl St., Denver, Colo.

J. S Allen and O. C. Kulicka have been appointed chief engineer and assistant engineer, respectively, of the Highway Commission of Washington County, Mississippi, and will have charge of road construction involving the building of about 150 miles of highway at an estimated cost of $950,000.

Messrs. C. F. Hess and R. E. Mitchell, of Point Pleasant, W. Va., and Mr. E. C. Smith, of Ravenswood, W. Va., have entered into a partnership under the firm name of The Ohio Valley Construction Co., and will engage in a general engineering and construction business, with headquarters and factory at Point Pleasant. Mr. Smith for the past five years has been in Panama as one of the engineers on the Isthmian Canal.

E. M. Anderson, Abbeville, S. C., has been elected president of the Tri-State Water and Light Association of the Carolinas and Georgia, at the recent annual convention at Macon, Ga. Other officers elected started as a rodman and having worked his way up through the vari- C., and W. T. Jones, Fayetteville, N. C., vice-presidents; and W. F. Stieglitz, Columbia, S. C., secretary-treasurer.

V. R. Parkhurst, Consulting Drainage Engineer of Topeka, Kansas, has been elected president of the recently organized Kansas State Drainage and Conservation Association. This Association, formed by representatives of all drainage boards in the state, will ask the legislature to invest drainage boards with the power to condemn property for flood protection, to amend the drainage law of 1905, providing for surveys for new drainage districts and necessary extensions of existing districts, to undertake topographical surveys of drainage basins, and to increase the authority of drainage boards generally.

H. R. Hershey, of Quarryville, Pa., has been promoted to the position of road superintendent of Lehigh and Northampton Counties, succeeding W. H. Pascoe, who resigned recently. Mr. Hershey has been with the State Highway Department for 10½ years, having started as a rodman and having worked his way up through the various positions to his present post. He was successively chainman, transitman, chief of party, and chief of construction. He has been attached for the last year to District Number 5, with headquarters at Allentown. Prior to his services at Allentown he was attached to the office of District Number 4, with headquarters at Clearfield.

## OBITUARY.

Joseph O. Osgood, Chief Engineer of the Central Railroad of New Jersey, dropped dead from heart disease at New York City on June 28th. Mr. Osgood was born in 1848 at Cohasset, Mass. He was educated in the high schools of that town and took the courses in Massachusetts Institute of Technology, 1872 and 1877. Entered railroad service in 1865 as rodman of construction of the Eastern Shore Railroad, now a part of the Pennsylvania system, since which he was consecutively to 1869 rodman and assistant engineer on the construction of various extensions. From 1870 to 1871 he was transitman and resident engineer on location and construction of the Portland and Ogdensburg Railway; from 1871 to 1873 he was assistant to the chief engineer of the Maine Central Railroad; from 1873 to 1878 he was resident engineer for the State of Massachusetts, on improvement of South Boston flats; from 1878 to 1880 he was division engineer of the Atchison, Topeka & Santa Fe Railway, on construction of the Colorado and New Mexico; from 1880 to 1882 he was chief engineer in charge of location and construction for the California and Southern Railroad; from 1883 to 1884 he was chief engineer of the Boston-Hooshe Tunnel and Western Railroad; from 1885 to 1886 was engaged in the making of examinations and reports on railroads; from 1886 to 1887 he was chief engineer in charge of rebuilding the Toledo, St. Louis and Kansas City Railroad; from 1887 to 1889 he was chief engineer of the Lake Shore and Michigan Southern Railroad. He was engaged in practice as consulting railway engineer in New York City from 1889 to 1901, and from that latter date to the time of his death he was chief engineer of the Central Railroad of New Jersey.

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[1] This requirement is fulfilled by the American Can Co.'s Gill style ointment box, deep pattern, 3 oz. capacity.

[2] Journal of Agricultural Research, Vol. V, No. 24, pp. 1125-1126.

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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## ANNOUNCEMENT OF THE WATER WORKS AND HYDRAULIC MONTHLY ISSUE OF "ENGINEERING AND CONTRACTING."

Readers of our weekly articles have, from time to time during the past decade, suggested to us the advisability of publishing a monthly magazine devoted to water works and hydraulics. There has been no such specialized publication, although the field for it has been large and steadily growing larger. We contemplated accepting the suggestion of our readers, and planned putting it into effect two years ago, but the war led us to "sit tight" for a while. In this issue we begin the execution of the new plan.

On the second Wednesday of each month the entire issue of articles in Engineering and Contracting will be devoted to hydraulics in its various applications, all of which are interrelated to a very considerable extent. Our contract news items will, of course, continue to cover the entire civil engineering field in this water works issue as in every other issue.

As one of our readers and advertisers suggests, this new monthly article service "will not only be economic in money, but, what is more important, economic in time." He refers to the time wasted in searching through a general magazine or paper for the articles that relate to the reader's specialty. As to the economy in money, the ability to secure a good monthly article service for $1 a year will be appreciated by many men, and particularly so where salaries do not keep pace with the rising cost of living.

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## THE GREAT UNDEVELOPED FIELD FOR WATER WORKS.

Water is a marketable commodity. Were as much ingenuity and energy expended in marketing water as in marketing electricity, there is probably not a water works plant in America that would not be able to double the quality of water sold.

It has become almost a fetish to talk only of saving water that is being wasted. But important as prevention of waste may be, it is vastly more important to increase the useful application of water. Yet when such a possibility is suggested, the question is immediately raised as to who will buy more city water save a very few. There are, it is true, some who still resort to wells for their supply, but their number in any city and in most towns is relatively small. Where, then, are we to find the new customers? The answer is largely in the persons of the old customers.

Almost every residence that has a bit of ground about it is a place where more water can be profitably used for six months of the year. Garden truck and fruit to the wholesale value of $500 to $1,000 an acre can be annually produced where intelligent irrigation is applied. A patch of ground 50 by 100 ft. is almost an eighth of an acre. At the retail prices of vegetables and berries, such a patch of ground can be made to yield annually fully $150 worth of food at retail prices, with no great labor on the part of its owner. Consider the number of such patches of land in any city or town, and it becomes at once evident that this market for water is very great, yet it is a market that has been scarcely touched.

Had water works managers employed the same methods that electric light and power companies have so successfully applied—namely, educational publicity in local papers and a sliding scale of rates based on metered service—there is no doubt that today we would be using not 100 to 150 gal. per capita but 300 to 500 gal. per capita during the crop raising season in nearly every city and town in this country.

Around every municipality there is a fringe—and by no means a narrow fringe—of residences dependent for water on wells subject to contamination. Under existing rates it may not pay to extend the water mains into such suburban districts, but under a metered system giving very low rates for large consumption of water, these suburban places would find it exceedingly profitable to use water in large quantities for irrigation. A water works that could not make a profit by selling small quantities of water to scattered consumers in the suburbs would profit greatly by selling large quantities to those same consumers.

Every man who has the slightest knowledge of the effectiveness of irrigation even in so-called moist climates will see the force of our argument, but it may be questioned whether the public can be induced to go into the raising of garden truck and fruit. We are confident that a very large part of the public can be led to this practice, provided proper publicity methods are employed. Our confidence rests upon the fact that already a goodly number of individuals have found it pleasurable as well as profitable to do a little farming in their back yards, applying less than an hour's work daily to the task. Children are easily encouraged to raise vegetables, and, with the aid of the public schools, it will not be difficult to teach them to become successful farmers on a small scale, raising all the "green stuff" and berries that are consumed in their homes during half the year.

Every city of homes—and that means every city in at least part of its area—should be a city of gardens. People should be taught how to make it so, how little it costs to make it so, and how certain are the garden crops when properly irrigated. They should be led to realize that vegetables and berries plucked fresh are infinitely more palatable than the inevitably stale stuff that the markets provide. Who, for example, has not noted the peppery taste of a radish fresh from the soil, and coincidently remarked upon the tastelessness of radishes bought in market? Who has not exclaimed, "Well, here is a real strawberry once more," as he rolled a ripe, luscious berry under his tongue, a berry plucked by his own hand?

Now, all this superiority of home raised "garden truck" is attainable by many at next to no cost, and is certain of being secured every spring, summer and early fall by the judicious use of an overhead sprinkling system in the garden patch.

As water rates now stand, as politics has been, as indeed we all have been—dead to the possibilities—water is used in but relatively small quantities where it should be used in great abundance—used, not wasted. Let us be done with our old ideals of a 100 gal. per capita, or less, daily consumption. Let us seek rather to increase the use of water in such manner as to add to the happiness and health of all residents of cities and towns. Let us change political boundaries, so far as water supply is concerned, reaching far out into suburban areas. Let us educate residents with yards, truck gardeners, owners of vacant lots and all who can raise vegetables and fruit, to use city water to increase and insure crops. There is no experiment involved in such a step, for many a watered back yard already bears witness to what can be done in raising berries and vegetables. "Back to the soil" right in our towns and cities, is a movement that every purveyor of city water should lend a hand to effect.

## THE WATER WORKS SUPERINTENDENT, THE AMERICAN WATER WORKS ASSOCIATION AND POLITICS.

At the recent annual convention of the American Water Works Association in New York, the criticism was made that "Superintendents' Day" was not made as fruitful as it might have been. Secretary Diven stated that the fault rested largely with the superintendents themselves, as he had received scant assistance from them. It is a deplorable fact that relatively few superintendents belong to this association, for it is a society that could be highly useful to every progressive water works official.

Undoubtedly one of the reasons why municipal water works superintendents have shown lax interest in plans for mutual assistance may be traced to politics. Men who secure public positions through "pull" are prone to regard all else as of minor importance in their official lives. Too many water works superintendents have, in the past, relied more upon politics than upon personal efficiency to hold their jobs. We say "in the past," for he is indeed blind who can not see that, in the future, efficiency is to be the standard by which municipal officials are to be judged. Toward that goal all cities are rapidly traveling, aided by bureaus of municipal research, by efficiency societies, by engineers in general and by water works associations.

The prime object of a water works association, as of any technical society, is to increase the efficiency of its members. This is mainly accomplished by exchange of ideas and the published records of work done and results secured. The superintendent who does not subscribe to this plan by joining a society and contributing to its discussions, not only injures himself but actually risks the ultimate loss of his position. If it be replied that the discussions of such a society are usually of a purely engineering nature and rarely of the sort helpful to a superintendent, then consider Mr. Diven's statement that the superintendents have themselves to blame.

Railway superintendents, electric light and power superintendents, and in fact the superintendents of almost every class of public utility, belong to associations and prepare valuable papers and discussions for presentation at meetings. Politics plays little or no part in their official lives. They realize that to hold their positions and to progress they must endeavor to increase their efficiency every year. A good many—but not enough—superintendents of water works have shown similar foresight. The time has come for all to join the efficiency movement, either relegating politics to the background or so aiding in its reformation that the name politics will cease to smell of "pork."

## ABOLISH "DEAD HEADS" FROM CITY WATER WORKS.

Mr. Allen Hazen, in his presidential address to the New England Water Works Association, said:

> On the railroads in the old days it was no doubt true that those who had passes caused more trouble and expense than other travelers. So I think in your water departments you will find that the dead-head takers are, in general, those who waste the most water, and that it costs the most to take care of. That which costs nothing is treated with but little respect. The schoolhouses that are furnished with free water will use gang closets or self-flushing closets to save a little money in plumbing, and the water will go pouring through them day and night because the janitor has not sufficient interest to shut them off at night because it costs nothing.

It is coming to be recognized—particularly in Wisconsin where all water rates are subject to the regulation of a state utility commission that every city department that uses water should pay the water department a fair price for the service. Not only does this lead to reduction in water wastage but it tends eventually to a more equitable distribution of taxes.

The biggest "deadhead" of all is the city fire department. It has been estimated in numerous water rate cases —and the editor has had part in several—that from 30 to 50 per cent of the "fixed charges"—interest, depreciation and taxes—of a water works plant should be entered against fire protection. This high ratio is of course not the result of a correspondingly large consumption of water for fire protection, but it results from the fact that all the water mains are made large enough to carry the "peak load" that comes upon them at the time of a big conflagration. So, too, the pumps and reservoirs are designed for this "peak load."

If the fire department were charged with, say, one-third the fixed charges of a water works plant, it would become apparent at once even to the least contemplative tax payer that all buildings and their contents should bear a fire tax with which to meet the fire department expense. Were this done, it would then follow that "fire traps" would have to pay such large taxes that it would no longer pay to keep them in use. Conversely the erection of fireproof buildings would be encouraged.

It may be stated as an economic axiom that economy is best fostered by charging to each department its proper share of the joint costs. This rule is broken by every municipality in more ways than one, but perhaps nowhere more frequently than in the "dead heading" of water to the different municipal departments.

## "WATER DISTRICTS" AND THE SUPPLY OF SEVERAL MUNICIPALITIES WITH ONE PLANT.

The most striking evolution in commercial electric lighting has been the growth of central power stations from which electricity is distributed to many separate municipalities. Although the reason for this electrical development are usually more pronounced than the reasons for a similar development in domestic water production and distribution, there is abundant economic justification for the grouping of water works plants in a manner not unlike the grouping of electric plants. Particularly does this become evident wherever water is brought from distant sources. But may it not also be shown to be economic to form "water districts" even where water is available close to a group of municipalities?

Water may be called a manufactured product wherever it is treated to remove organic or inorganic matter. Treatment of one kind or another is required in the majority of cases where water is secured from sources near to human habitation. Manufacture is invariably cheaper when conducted on a large scale, not only because the manufacturing plant is operated at a higher "load factor"—more continuously at a load approaching its capacity—but because the working force turns out a larger number of units of product. This holds as certainly of treated water as of generated electricity or of smelted copper. We believe, therefore, that "water districts," comprising several distinct towns and cities, can profitably be organized in nearly all densely populated localities where water is or should be treated.

The transmission of the manufactured water can be effected from a central producing plant to local reservoirs and thence distributed through existing pipes.

A water district can afford to hire the best of engineers and chemists and thus maintain higher standards both of purity of supply and of economics of performance. The local water works managers will, in turn, greatly profit as a result of the superior organization of which they will be a part. There will open before them a prospect of advancement to higher positions and correspondingly greater income. What man does not lose ambition when no further "worlds to conquer" are in sight?

## EDITORIAL PARAGRAPHS.

The number of railway stockholders on June 30, 1915, was 626,122; the mileage of railway represented was 257,211 miles. The number of individual holders of railway stocks is of course something less than that given above as many persons hold stock in several railways. The average holding per stockholder at par value was $13,796. This figure is reduced to $9,882 if stock held by the railways themselves is deducted. Exclusive of railway holdings there were 607,630 railway stockholders in June 30, 1915.

To the promoter is due most of the progress of the world. Yet so demeaned has the word promoter become in popular thought that a prominent hydraulic engineer writing on the economics of water power development confessedly is afraid to use the word and substitutes the term "projector."

There is one ray of hope in the recent action of Congress against "efficiency methods" in government factories. This action effected merely amendments to the fortification and army and navy bills. The Tavenner bill which extends the prohibition to all government work, "owing to an unfavorable place on the calendar is not likely to pass."

The American Water Works Association now numbers more than 1,330 members, having made a net gain of 103 members during the last year. Let it now be determined to add 500 new members before the next annual convention at Richmond. It can be done and it should be done.

Mr. Leonard Metcalf, who was elected president of the New England Water Works Association a year ago, has just been made president of the American Water Works Association. It would seem that Mr. Metcalf, standing so high in the opinion of the members of both societies, might be instrumental in merging the two into one society. Yet he has thus expressed the opinion that such a merger would be premature at this time: "A consolidation, if it does come, must come gradually and not by forced effort." But this need not mean any reduction of effort to educate all the members of both societies to regard a union as ultimately inevitable because of the relative inefficiency of divided efforts.

The appointment of sanitary engineers, instead of physicians, as public health officers, has been repeatedly urged by Mr. M. N. Baker. The idea is worthy of more general and aggressive support on the part of engineers. But most engineers have yet to learn the importance of united effort in matters of public concern affecting also the interests of engineers. The public, unless engineers take united action, will remain in ignorance of such facts as that reduction in typhoid fever is attributable almost entirely to engineering works.

Why will a subaqueous water main freeze in sea water which does not freeze in ordinary winter climates and not freeze in fresh water, which does freeze in the same climates? The question is suggested by the article in this issue describing the freezing of an under sea water main. Its answer is given by the writer of this article: In fresh water the blanket of ice prevents excessive radiation and the water beneath is always warmer than 32 degrees. In sea water an entirely different condition exists. During a period of protracted frost sea water may easily reach a temperature several degrees below 32 degrees. It has no surface blanket of ice. It is usually in motion and laving the bare iron pipe it veritably sucks the heat from the water in the main. Because of this same action the efficiency of the electric current is reduced as a means for thawing frozen mains lying under salt water.

## IMPROVED TAMPER FOR CONCRETE.

To the Editor: The "Improved Tamper for Concrete" illustrated on page 587 of the June 28th issue of your paper is not new. I have personal knowledge of the use of such a tamper 37 years ago, which led me to have one made 26 years ago for some sidewalk work. It may be 100 years old, for the men from whom I got the idea seemed to look on it as a very old idea.

I used it in my work many years and described my methods for sidewalk construction, using such a tamper, several years ago in Engineering and Contracting.

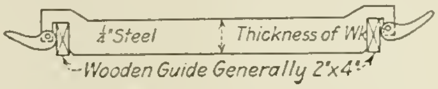
Yours truly,
Ernest McCullough,
Consulting Engineer.

Chicago, Ill., July 3, 1916.

## AN IMPROVED TAMPER FOR CONCRETE AND A HANDY SIDEWALK TEMPLATE.

To the Editors: On pages 587 and 588 of last issue of Engineering and Contracting you describe "An Improved Tamper for Concrete," contributed by R. J. Borheck, Contracting Engineer of Tacoma, Washington. We note in closing the article it is stated that patents have been applied for, etc.

For the readers' information and the contributor's as well, we desire to say that for the past seven to eight years the writer and several of our local contractors have used tampers of this kind; in fact, almost identical in design to the one illustrated; being made up of various dimensions for the base. How patents can be obtained on old ideas of this kind is almost unbelievable.



Sidewalk Template.

We have used a sidewalk template for nearly twelve years of which we enclose a sketch, that might be of interest to some of your subscribers. Perhaps a patent should have been applied for on this template, but we thought better to use it and let others use it for the good of the fraternity.

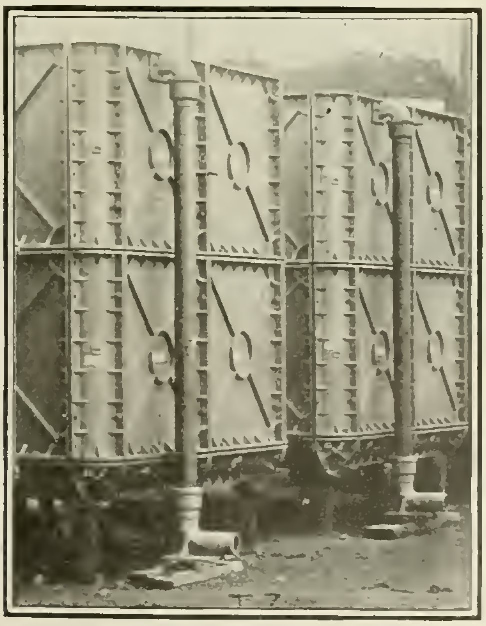
Very truly yours,
The F. C. Dreher Contracting Co.

Denver, Colo., June 29, 1916.

## CAST IRON WATER TANKS FOR GOLD COAST RAILWAYS, AFRICA.

Contributed by Frank C. Perkins, Buffalo, N. Y.

Small cast iron tanks are extensively used by the Gold Coast Railways in the English Colonies; each tank is 8 ft. square and 8 ft. deep with a capacity of 3,200 gal. The details of construction of these English cast iron tanks are of special interest. The thickness of the plates, ribs and flanges and the diameter and pitch of the connecting bolts are determined according to the unsupported area of the plates, and the pressure per unit of area to which they are subjected when forming part of a tank.



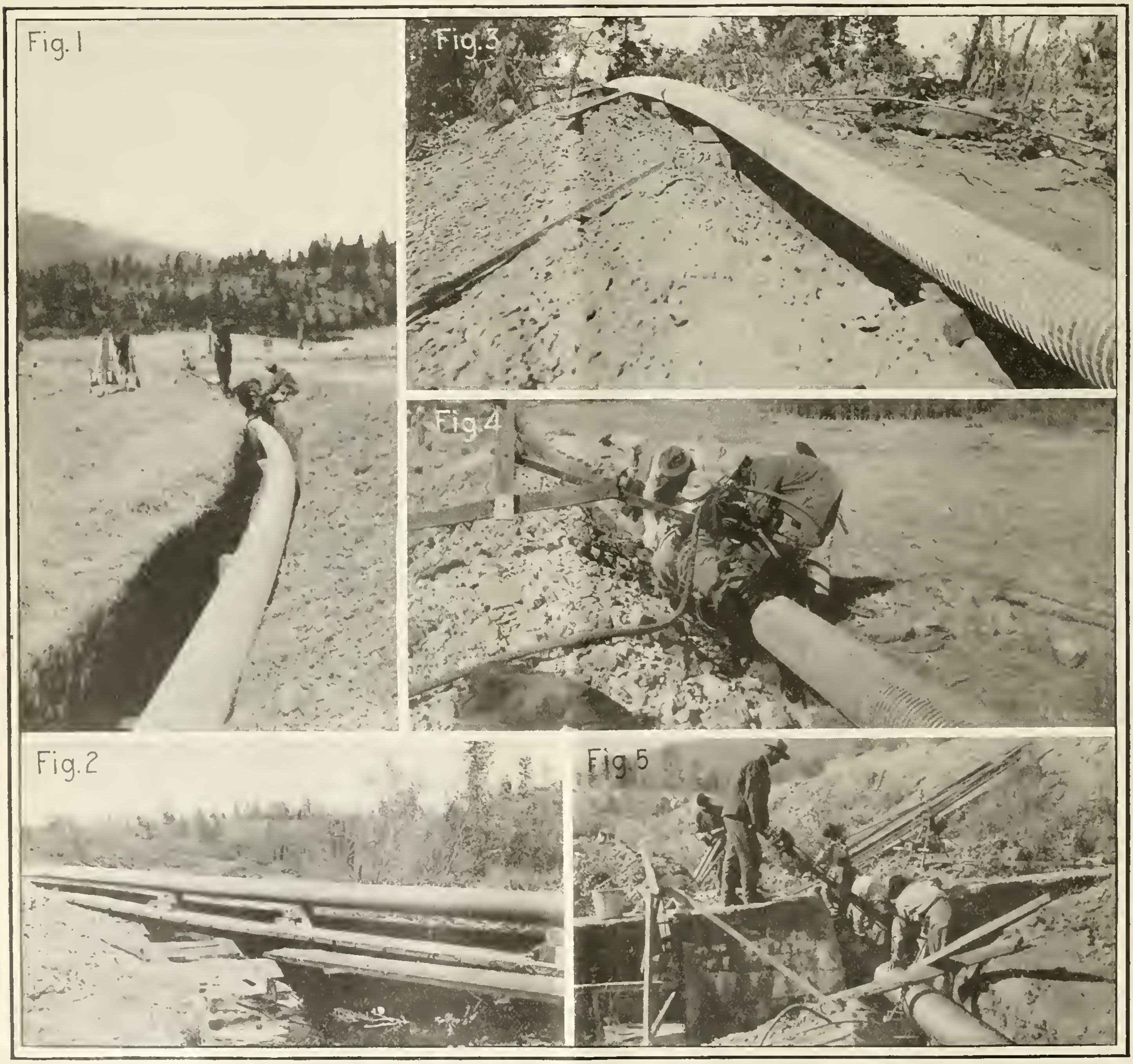
English Cast Iron Water Tanks.

The flanges are bracketted between the bolt holes, the latter are cored and slightly oblong to provide for expansion in use, and by adopting radial or cross ribs on the body of the plates, the engineers are enabled to provide the greatest possible resistance for the weight of material used. The tie rods are also designed and located with special care. They are adjustable in length and are connected to the plates at the points of greatest resistance. The flanges are machined their full width dead square, with the cut running in the longitudinal direction, forming fine ridges which retain the jointing material between the flanges when they are bolted together. The plates are cast of selected iron, machined and fitted together at the works in Sheffield. These tanks being also constructed with the joints arranged to caulk with iron cement.

## A 6,500-FT. CONTINUOUS WIRE WOUND WOOD STAVE PIPE LINE IN CALIFORNIA.

Banded wood stave pipe lines and lines of lengths of wire-wound wood stave pipe connected by joints are common. The illustrations show various features of a wood stave pipe line on which the wire winding was put as the pipe was laid and is continuous for the entire 6,500 ft. of pipe. This pipe is 10 in. in diameter and is wound with No. 4 galvanized steel wire spaced from 11/16 in. to 27/16 in. A total of 180,000 ft. of wire was used, was wound mechanically by a special machine, was welded at 120 points by a special device and was coated with asphalt also by a special device. The illustrations indicate all the general construction features, and the characteristics of the line, but the special construction methods require description.

The pipe is built supported over the trench into which it is lowered as suitable lengths are completed. The stave laying follows the usual methods except that the joints are staggered at will. As fast as laid up they are wound. The winding is done by a special device consisting of a gear wheel encircling the pipe and driven through a speed reduction gearing by an electric or compressed air motor. As the gear wheel is rotated around the pipe it at the same time travels along the pipe. The wire from a reel which encircles the pipe ahead of the winding machine is threaded through rollers carried by the rotating gear and which give the required tension and as the gear rotates is wound around the pipe. When the end of a reel of wire is reached to it is electrically welded the end of another reel and winding proceeds as before. The



LAYING CONTINUOUSLY WIRE-WOUND WOOD STAVE PIPE LINE FOR CALIFORNIA PINE BOX & LUMBER CO., DELLEKER, CAL. Fig. 1—View Showing Horizontal Curve in Line. Fig. 2—View Showing Constructed Pipe Before Lowering. Fig. 3—View Showing Vertical Curves in Line. Figs. 4 and 5—View Showing Winding Operations in Progress.

electric welder is carried along the trench as needed. It galvanizes the weld. To coat the wound pipe another device is used. It consists of a sleeve slightly larger than the wound pipe and having elastic and flexible ends of a fabric which hugs the pipe closely. By means of a funnel this sleeve is kept filled with hot asphalt and by pulling the sleeve along the pipe the asphalt is smeared evenly over the wire and staves. As a sufficient length of pipe is completed it is lowered into the trench.

The operation of pipe construction by the new process is continuous. There are no joints. The pipe can be bent to curves; on the line illustrated there were curves of 30°. Ordinary 60-000-lb. tensile strength wire is used, the diameter and spacing being according to the pressure on the pipe. The pipe line illustrated was built for the California Pine Box & Lumber Co., Delliker, Cal., by the Continuous Wire Wound Pipe Co., San Francisco, Cal.

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## WATER SUPPLY FOR TROOPS IN THE FIELD.

Contributed by Jack J. Hinman, Jr., Senior Water Bacteriologist and Chemist, State Board of Health Laboratories, State University of Iowa, Iowa City, Iowa.

It is quite as necessary to supply a water of unobjectionable quality for troops in the field as it is to supply water of like quality for cities and towns in time of peace. Conditions in the field make the provision of satisfactory water dependent upon a very different set of factors. In the field the selection of a supply is directed by expediency. It is often impossible to secure water from unpolluted sources. Owing to the exceptionally large temporary population, with comparatively meager sanitary arrangements for excreta disposal, the pollution of the water may be of a particularly dangerous character as well as of high concentration. The great number of men gathered into a locality may call for an amount of water in excess of that which has been provided by the local inhabitants in time of peace, thus necessitating the fullest use of all wells and streams.

The accidental and deliberate befouling of the water of streams and wells by a retiring enemy is to be expected. It is easy to conceive of the poisoning of water-supplies by means of chemical poisons. Cultures of pathogenic organisms might be used.

Permanent camps in the vicinity of towns possessing water works may have potable water supplied by pipe lines or carried to the camp in tank-wagons. It would be necessary to have control of the operation of the plant and to keep them under careful guard to avoid interference. Rapid sand filtration plants, such as are used in city water works, could be constructed in a few weeks' time. For a rapidly advancing army their use would be impracticable.

The advance troops are dependent for the most part on raw water or water which has been treated by chemical sterilizing agents alone, rather than by the more satisfactory process of coagulation and filtration followed by such sterilization. The water of streams has usually been protected merely by posting guards to see that all fording, bathing and watering of animals is done well down-stream from the designated source of the drinking water. Wells and springs known to be bad are carded or preferably put under guard. Men on patrol duty, advance parties, and men occupying exposed trenches or rifle pits must carry with them enough pure water to last until they can be relieved, or they must depend on the water of any available well, ditch or trench. The use of hot drinks, such as tea and coffee, is encouraged.

It is essential for any army advancing into unknown or hostile territory to know the condition of the water of all available supplies. This must be quickly accomplished, and until the actual knowledge is at hand, the water must be treated as if it were known to be heavily polluted. This work must be entrusted to specially trained men, and since they must work up to the first line, their duties are quite hazardous. I know of one German chemist who has lost his life in Belgium while collecting water samples. The British army entrusts this work to a combatant organization known as the Sanitary Corps. In our army the Medical Corps is responsible.

Many schemes have been proposed for the field examination of water. Most of these are attempts to make a rapid chemical examination, since the chemistry of polluted waters received attention long before the bacteriology of such waters.

The British army has for years had an official water-analysis case which could be carried as a part of a man's pack. It provided for the determination of chlorine, nitrites, nitrates, oxygen consumed and even the total solids and the ammonias. The Nessler's solution was provided in sealed tubes, but the other chemicals were furnishd in tablet form. In this detail the outfit resembles the U. S. G. S. field analysis case,[1] which likewise furnished the chemicals in tablets. The writer's experience with this case was that while the analyses could be readily carried out, the method required more time and was much more cumbersome than the ordinary laboratory procedure. To attempt to determine the ammonias in the field would seem unnecessary and consuming too great an amount of time, unless direct nesslerization were all that was attempted.

The present European war has brought out a variety of field analysis procedures. Vergnoux[2] recommends that only the nitrite (Griess' method) ammonias and chlorine be determined. He properly notes that the chlorine determination is not indispensable. The Annales de Falsification[3] prints a set of instructions for analysts in the field. This includes directions for the nitrite, ammonia, chlorine, oxygen consumed, and even the hardness determinations. Since chemical poisoning is to be reckoned with, special methods applicable to the detection of these have been devised. Kohn-Abrest[4] has prepared an ingenious scheme in which he looks for chlorine, sulphur dioxide, bromine, organic iron salts, arsenic, nickel, cobalt, barium, lead, cyanogen, alkaloids and the glucosides. Fleury[5] uses four reagents, hydrochloric acid, sodium sulphide, strontium sulphate and sodium picrate paper, Grignard's reagent for hydrocyanic acid. With the aid of these he is able to detect in the field arsenic, antimony, mercury, copper, lead, tin, zinc, aluminum, barium, cyanides and nitroprussides.

The bacterial examinations may be carried out in base laboratories or in mobile field laboratories. A number of rapid methods are available in addition to the usual laboratory procedure. Muller[6] has a method for counting bacteria after precipitation from a known amount of water by use of basic ferric chloride. The micro-plate devised by W. D. Frost might be useful. This depends upon staining with methylene blue the colonies growing on a very small agar plate, after 6 or 8 hours' incubation. The count is made at a low magnification. Attempts at identification of bacteria would naturally take a longer period of time.

One method by which the sterilization of a water is verified consists in planting the same amount of water in each of a series of flasks of nutrient broth. Decreasing amounts of chemical have been added to each sample of the water. The last flask to remain clear on 24 hours' incubation contains the right amount of sterilizing agent.

Almost every conceivable method of water purification has been tried for army use. This includes filters, ultra-violet ray and ozone sterilizers, heat sterilizers and a great variety of chemical sterilization methods. Coagulation is not usually classed as a chemical sterilization because it represents a more mechanical removal of impurities than the addition of a germicidal substance does.

Heat may be used to prepare distilled water. It may also be applied in a manner similar to that of the ordinary household sterilizer. In this apparatus water rises through a tube to a boiler, is heated to boiling and then passes down an inner tube enclosed within the first, giving up its heat to the water rising in that tube and being itself cooled to a point very little above the temperature of the raw water.

Filters of every sort, from complicated pressure filters to a filter candle designed to fit into the mouth of a canteen, have been in use. The more complicated ones have generally required specially trained men and special supplies and hence have given trouble in operation. The Japanese used a small filter, called the Ishiji filter, in their Manchurian campaign. The Darnall filter[7] has been used by our troops. This is a small portable filter, greater in capacity than the Ishiji filter, designed by Maj. C. R. Darnall of the Medical Corps. It has a capacity of 50 gal. per hour and operates by siphoning the water through a filtering cloth. A coagulant consisting of aluminium or iron sulphate and lime, potash or soda is supplied. It is not necessary to sediment after coagulation. The German army has special 7-candle Berkefeld filters, which yield 2,000 liters per hour.

The use of roughing filters, with or without a coagulant is necessary to secure satifactory and economical purification when using the ultra-violet rays, ozone or other chemical disinfecting agents. Christian[8] has used a simple device consisting of a barrel with perforated bottom, containing a layer of stones and layers of sand, ashes or charcoal. This will remove clay, algae, or protozoa, although a coagulant, such as aluminium sulphate, may be necessary where the water contains much colloidal material. In the Lyster apparatus, mentioned below, a strainer of Scotch outing flannel is used with turbid water. This, of course, would be but partially successful in the presence of colloids.

Owing to the perfection of purification apparatus for cantonments and other permanent camps, the recent tendency has been to give most attention to the devising of means for the purification of water for individual soldiers and small bodies of troops in the field. These processes must be simple, capable of being carried out by any of the men. The chemical germicides are particularly well adapted to this sort of use. With most of the schemes involving their employment, the usual European method of application is followed. This consists in heavily overtreating the water and then nullifying the excess of the chemical by the addition of a second reagent, usually sodium thiosulphate. Nearly all of these processes are based upon the use of potassium permanganate, iodine, bromine or chlorine, as the active germicide. The reactions involved are therefore oxidizing reactions.

Potassium permanganate has been widely used by the British army in their Indian campaigns, as well as for the protection of the soldiery and civilians during cholera epidemics in India.[9]

The French Government is now using permanganate for the sterilization of water by individual soldiers while in action (Henri Penau).[10] A case is supplied which consists of two empty Lebel cartridges, soldered base to base. Into one is filled a mixture of 50 parts potassium permanganate, 30 parts dry sodium sulphate and 20 parts calcium carbonate. Into the other cartridge is put a mixture of 35 parts sodium thiosulphate, 35 parts dry sodium sulphate and 30 parts calcium carbonate. Aluminum slip-caps are fitted to the ends of the cartridges. These caps serve as measuring cups. In use, one cupful of the permanganate is put into a liter of water and after two minutes or so, the excess permanganate is removed by the addition of a cupful of the sodium thiosulphate mixture. One outfit holds enough chemicals for the treatment of 40 to 50 liters of water. Since permanganate is more satisfactory than the halogens for turbid waters its use is suggested for turbid supplies which can not be filtered.

A variation of this process consists in a combined permanganate and copper sulphate method, for which a German patent[11] (No. 281,810, June 7, 1913), has been allowed. The salts are provided in the form of tablets. The reason given for the addition of the copper sulphate is that it stimulates the liberation of oxygen from the permanganate. After 10 minutes action hydrogen peroxide is added, causing the manganese and copper to be precipitated as oxides. After-filtration is necessary. Filters are said not to require cleaning as often as do most filters, since the copper in the sludge acts on the spore-forming bacteria and prevents bacterial growth through the filter.

Iodine has been advocated by French and Italian authorities. Vergnoux recommends a 10 per cent solution, with ½ per cent potassium iodide in 80 per cent alcohol. Five drops of this solution is sufficient for one liter of water. A few drops of saturated sodium thiosulphate solution destroys the excess iodine. Penau add a special tablet, containing .85 gram of iodine, to 200 liters of water. After 30 minutes' action two grams of sodium thiosulphate are added to destroy the residual iodine.

Bromine was tried out in the Sudan campaign of 1898 and found to be difficult and unreliable. Its use was advocated by Schumburg,[12] who used a solution of 20 parts bromine and 20 parts potassium bromide in 100 parts of water. One cubic centimeter of this was added to 5 liters of water and the excess was converted into ammonium bromide by the use of a volume of 9 per cent ammonium hydroxide equal to the volume of bromine solution used. Later Schumburg suggested the substitution of sodium thiosulphate for the ammonia. This method has been revived by Dr. Regel, who is quoted by Aumann[13] as advising the use of the same quantities of bromine and potassium bromide as were used before by Schumburg, but dissolving them in 25 per cent hydrochloric acid, instead of water. Satisfactory results are claimed. A caution is given against packing the solution in ampoules since the solution would be likely to cause damage in case of breakage. Other German scientists have tried bromine and found it unsatisfactory.

As would be expected, the greater number of methods are based on the use of chlorine. For the larger camps sterilization of water by liquid chlorine or calcium hypochlorite may be carried out in the ordinary way, but for field sterilization the chlorine is provided as tablets or capsules of calcium or sodium hypochlorites or similar products, or in the form of Javelle water or antiformin. Javelle water is prepared by adding sodium or potassium carbonate to calcium hypochlorite suspension, thereby precipitating the calcium as the carbonate and forming sodium or potassium hypochlorite. After settling, the clear liquor is used. Antiformin is similar, but it contains a large amount (about 30 per cent) of sodium hydroxide as well. As mentioned above, the water is heavily overtreated and an amount of available chlorine many times the quantity that would be applied in an American water works is used.

Penau adds 10 cubic centimeters of Javelle water, containing 5 per cent available chlorine, to 100 liters of clear water or he adds 2.5 grams of calcium hypochlorite, containing 20 per cent available chlorine. After 5 minutes the addition of 5 grams of sodium thiosulphate removes the excess chlorine and its objectionable taste.

Rheins'[14] method consists in adding to every liter of water 2.1 cubic centimeters of concentrated antiformin and 1.1 cubic centimeters of 25 per cent hydrochloric acid. The chlorine may reach as high a concentration as 110 parts per million. The excess is removed after 5 minutes by 0.45 gram of sodium thiosulphate, while 1.7 grams of bicarbonate of soda are added to take care of the acid. The water has a slight alkaline taste, and is sterile.

Vincent and Gaillard[15] prepare a series of tablets suitable for 1, 5 and 10 liters of water. These contain .015, .075 and .150 grams of calcium hypochlorite and .08, .38 and .60 grams of salt, respectively. They yield 3 to 3.5, 17 and 35 milligrams of available chlorine. Action is complete after 30 minutes. The tablets will retain their strength for several months if kept cool and dry. In some respects these tablets remind one of the capsules which were prepared by the Minnesota State Board of Health from hypochlorite and sodium carbonate.

Ditthorn[16] uses 0.2 gram of a new preparation in powder form said to contain 75 per cent available chlorine. This will sterilize 1 liter of heavily polluted water. Ten minutes is allowed for sterilization. The excess chlorine is removed by adding 0.4 gram of "ortizon," a stable compound of carbamide and hydrogen peroxide. The water is turbid, but need not be filtered.

Rolland's[17] method is simple. He adds enough calcium hypochlorite to a quantity of water to give it a distinct chlorine taste. Afterwards he filters it through a funnel containing alternate layers of charcoal and cotton. This is to remove the taste.

A device now in use in the United States Army is the canvas bag devised by Maj. Wm. L. Lyster[18] of the Medical Corps. This is simply a canvas bag 24 in. in diameter by 28 in. in height, weighing when empty about 7½ lb. Five self-closing faucets are provided near the bottom to make dipping up of the treated water unnecessary. In use it is filled with water and a tubeful of calcium hypochlorite, about 15½ grains, is sprinkled on the surface of the water. It is not necessary to stir the hypochlorite into the water. In 5 minutes the water is claimed to be fit for use. The bag is provided with a strainer of Scotch outing flannel for roughly filtering turbid waters.

As has been said above, these hasty chemical processes are not capable of purifying a water as well as the methods involving the use of special apparatus, such as filters. It is with turbid, muddy waters that the chemical processes fail most completely. However, the special apparatus required for the more perfect purification —even that of a transportable type—is often too far behind the troops to be of any use to them. It is then that the chemical processes reach their greatest importance.

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## STEEL WALL FORMS FOR IMHOFF TANK CONSTRUCTION AT COLUMBUS SEWAGE TREATMENT PLANT.

(Contributed.)

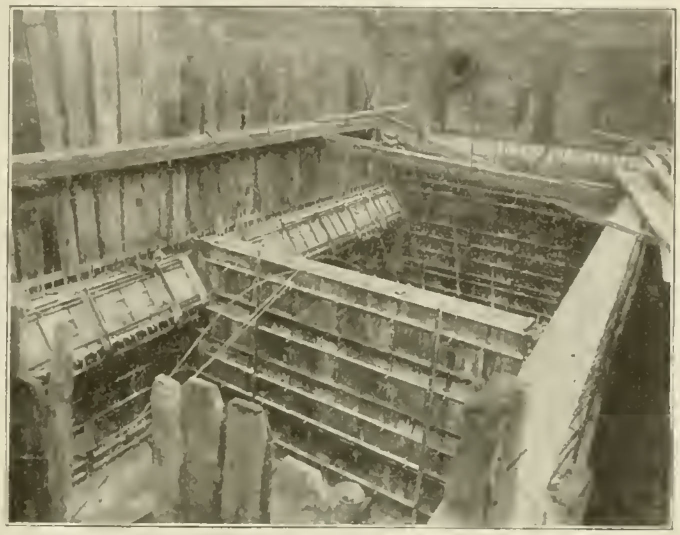
Without causing a complete shutdown at the Columbus sewage treatment plant, the original settling tanks are being converted into Imhoff tanks by the use of light steel wall forms in standard units, supplemented by specials for intersections of surfaces in different planes. While half of the tanks are thus being modified, the other half are continued in operation, taking the entire flow of the plant. The outer walls of the original tanks are left in place and are used as the outer walls of the Imhoff tanks. The work, naturally, is being spread through two seasons.

The contractor for this work, D. W. McGrath, of Columbus, O., is using Blaw light wall forms for practically all of the new work, excepting the end channels for the admission and outflow of the sewage. The latter are of such variable form as not to permit a sufficient amount of re-use of the forms to justify the use of steel.

The first operation consists of excavating below the bottom of the old tanks and constructing pits with concrete walls and sumps in their bottoms for the collection of the sludge. The forms are set up for one of these pits complete, a height of 8 ft. above the top of the sump. These forms are filled and removed before the wall is carried up higher, being used again on another sump as soon as they are taken away from the first one constructed.

The illustration shows the steel forms filled with concrete for the construction of one of these sumps. The system of liners holding the forms rigidly in position is well shown, and it will be noted that on the overhanging wall the liners are bent so as to produce a wall of exactly the right profile.

The forms used on this work are, with the exception of the specials provided for the intersections, strictly standard light wall forms, adjustable for use on all plain wall work, where the height poured at any one time does not exceed 10 ft. These forms are attached to the liners before they are erected and may be shifted either in units 2 ft. wide and 10 ft., 12 ft., or 14 ft. long, as desired, with the horizontal liners attached, or in larger units with the vertical liners attached, in which case it is necessary to employ a derrick to handle the form on account of the weight. The form weighs about the same per square foot of surface as a well-made wooden form, but occupies less space and has much greater stiffness.



Steel Forms for Imhoff Tank Walls.

On this particular job the forms used in the sumps were shifted by the derrick in units 12 ft. wide by 8 ft. high or 96 sq. ft. to a unit, similar units being used in the upper sections. In shifting these large units, they are picked up by the derrick and swung around into a new place wherever desired, necessitating little handling.

## COST OF THE CITY TUNNEL OF THE CATSKILL AQUEDUCT, NEW YORK WATER SUPPLY.*

The city tunnel is 18 miles in length from Hill View reservoir to the terminal shafts in Brooklyn, and its finished diameter is 15 ft. for the first 8 miles reducing from this size by successive decrements of 12 in. to 11 ft. in Brooklyn. Of the 24 shafts through which the tunnel was constructed, 22 were built as waterway shafts through which the Catskill supply could be delivered to the street mains. Shaft 1, a construction shaft, was plugged and Shaft 11 has no waterway. Two shafts, 11 and 21, both located at low points in the tunnel profile, were built as drainage shafts through which to unwater the tunnel for inspection and repairs.

Some minor work remaining to be done does not permit of final exact costs being given, but the following figures are substantially correct:

| | |
|---|---|
| Preliminary Investigations: | |
| Borings, Contracts 38, 73, 98 | $ 171,942 |
| Surveys and studies | 189,357 |
| | $ 361,299 |
| Real Estate: | |
| Awards for tunnel easement and shaft property | $ 314,414 |
| Expenses of condemnation | 35,904 |
| | $ 350,318 |

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*Extract from a paper by Walter E. Spear, Department Engineer Board of Water Supply, New York City, in the Journal of the American Water Works Association for June, 1916.

Construction:

| | |
|---|---|
| Tunnel Contracts 63, 65, 66 and 67 | $18,415,000 |
| Equipment contracts | 880,000 |
| Superstructures | 150,000 |
| Engineering | 950,000 |
| | $20,395,000 |
| | $21,106,617 |

The unit costs of the several sizes of tunnel based on the estimated final quantities and the contract prices, and exclusive of preliminary work, real estate, superstructures and engineering, are shown in Table I:

TABLE 1.—ESTIMATED COST OF THE CITY TUNNEL.

| Diameter of tunnel, ft. | Length of tunnel, ft. | Number of shafts. For const'cion only. | For wa'rway access and drainage. | Depth of shafts Minimum, ft. | Maximum, ft. | Total, ft. | Cost of tunnel per lin. ft. Tunnel only. | Total, incl. shafts and equipment. |
|---|---|---|---|---|---|---|---|---|
| 15 | 38,926 | 1 | 8½* | 218 | 477 | 2,910 | $146 | $195 |
| 14 | 26,247 | 0 | 7 | 220 | 447 | 1,954 | 151 | 202 |
| 13 | 4,553 | 0 | 1 | 204 | 224 | 214 | 146 | 182 |
| 12 | 9,080 | 0 | 2 | 204 | 749 | 1,005† | 141 | 204 |
| 11 | 15,096 | 0 | 1½* | 318 | 757 | 2,305† | 139 | 249 |

*Where tunnel diameter changes, one-half cost of shaft is charged to each size tunnel.

†Lengths of tunnel and depths of shafts are according to original profile on which payment is based.

## TYPICAL DESIGNS OF CIRCULAR REINFORCED CONCRETE RESERVOIRS.*

Figure 1 shows in cross-section the wall and part of the bottom of a 2,000,000-gal. reservoir, 120 ft. inside diameter, 19 ft. 10 in. deep at the wall, and 24 ft. 10 in. deep at the center. This reservoir was built partly in excavation and partly in embankment on clay soil. Its bottom, which was 5 in. thick, was reinforced throughout with steel sufficient only to resist temperature stresses. The reinforcement in the wall was continuous around the circumference, and was designed to resist the internal pressures just as the hoops on a barrel resist the internal pressures in the barrel.

Figure 2 shows in cross-section the wall of another reservoir in which the steel reinforcement was stressed as are the hoops in a barrel. This wall was built to enlarge the capacity of an existing reservoir by increasing its depth from 14 to 32 ft. The inside diameter of the reservoir, as enlarged, was 142 ft., and its capacity about 4,000,000 gal. Right along side of this old reservoir was constructed a new one which was so designed that the part of it which showed above the finished grade should be an exact duplicate of the enlarged old reservoir, and Fig. 3 is a section through the wall of the new reservoir. Here again the reinforcing steel is subjected to hoop stresses.

Criticising his own work in the light of later experience, the writer would say that in designing the wall shown in Fig. 3 he made a mistake in putting all of the steel near the inner face of the wall and none of it very close to the outer face. The practical result of this was that in the cold weather which followed shortly after the construction of this reservoir, vertical cracks showed up in the outer surface of the wall all the way around at distances of 20 or 25 ft. apart. These cracks were visible only near the bottom where the wall was thickest and where the bulk of the concrete lay outside of the reinforcing steel. None of them went through the wall, and no leakage resulted from these cracks, so that they did no harm except to cause some unnecessary alarm when they were first discovered. They are not now in evidence, as the earth embankment around the reservoir covers the lower fourteen feet of its height.

Figure 4 is a section through the wall of a reservoir of 10,000,000 gal. capacity. The diameter of this reservoir is 300 ft., and its depth at the wall 15 ft., and at the center 25 ft. The bottom is reinforced throughout to resist temperature stresses, and the wall is designed as a cantilever gravity section, with only enough steel around the circumference to resist temperature stresses. This reservoir is believed to be the largest reinforced concrete reser-

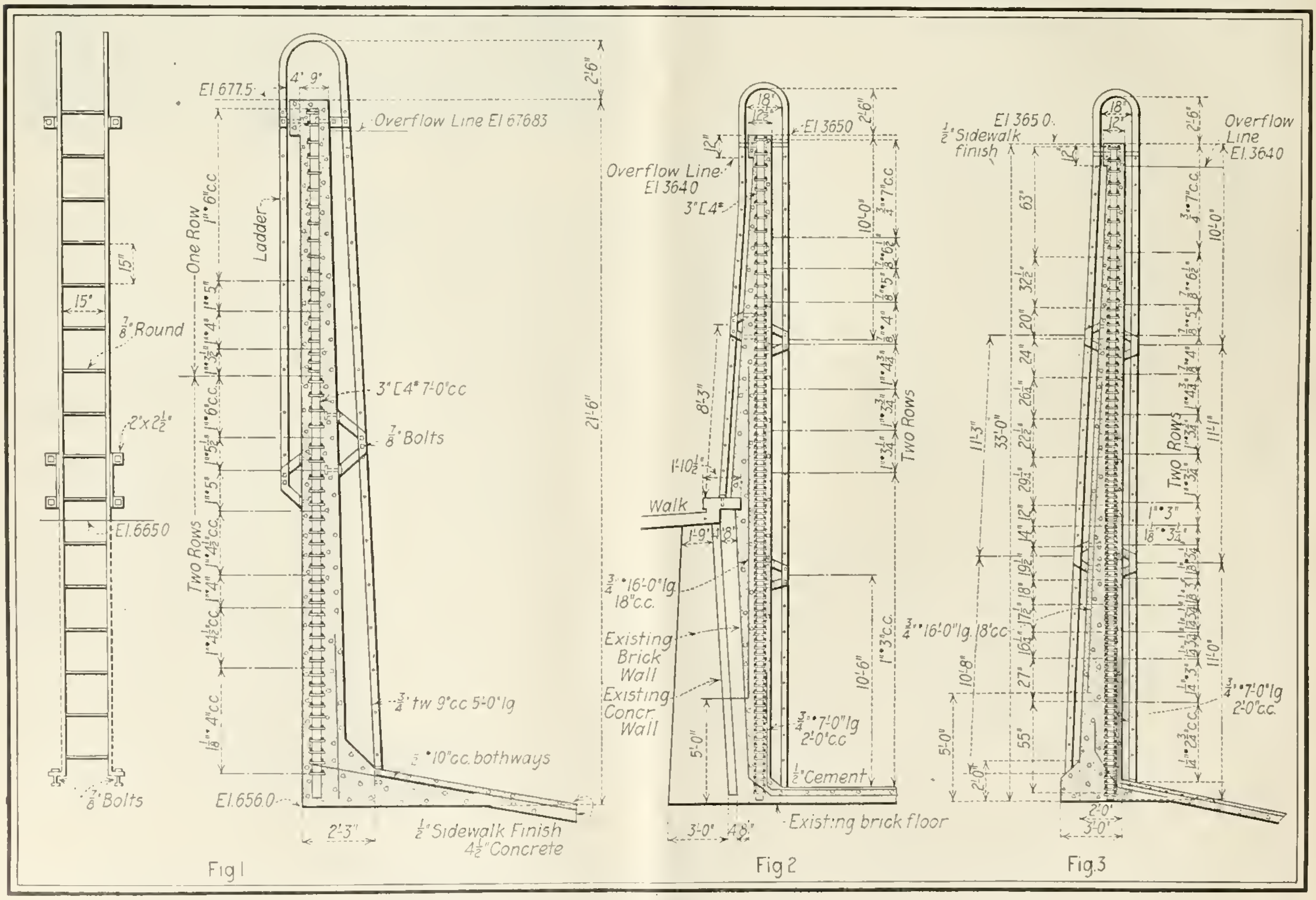

Fig. 1—Wall Section and Ladder Detail of 2,000,000-Gal. Reservoir 120 Ft. in Diameter. Fig. 2—New and Old Wall of Enlarged Reservoir 142 Ft. in Diameter. Fig. 3—Wall Section of 4,000,000-Gal. Reservoir.

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*Extract from a paper by Dabney H. Maury in Journal American Water Works Association for June, 1916.

voir ever built without expansion joints. It was built in 100 days, and was practically watertight when finished.

Figure 5 is a section through the wall of a 7,500,000-gal. reservoir built almost wholly in excavation, a considerable portion of the excavation being stratified limestone rock. The diameter of this reservoir was 180 ft., and its depth 42 ft. In this case the lower part of the wall was thin and was built solidly against the rock, while that portion of the wall above the rock was constructed as a continuous slab supported by buttresses carried down to the rock, the height of the thick portion of the wall and the height of the buttresses varying with the elevation of the upper surface of the solid rock.

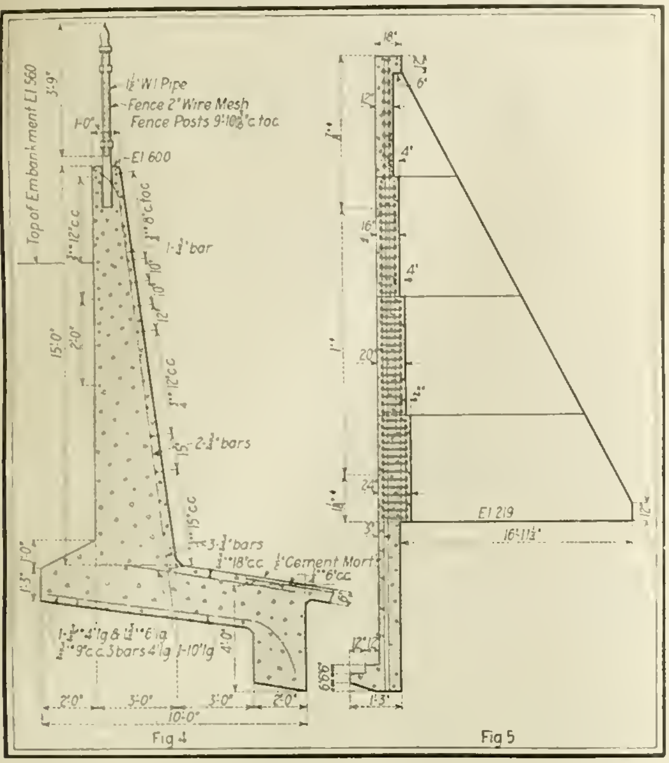

Fig. 4—Wall Section of 10,000,000-Gal. Reservoir 300 Ft. in Diameter.
Fig. 5—Wall Section of 7,500,000-Gal. Reservoir 180 Ft. in Diameter.

It will be noted that in the first three cases shown the reinforcing steel was stressed hoop-fashion, but that in the larger reservoirs of 10,000,000 and 7,500,000 gal. capacity, respectively, the hoop method was not used.

While no definite line can be drawn, it is thought that the 4,000,000 gal. reservoirs, which were 142 ft. in diameter by 32 ft. deep, were fairly close to the limit of size in which the hoop method of reinforcing could be economically employed. For capacities greater than these, the amount of steel required per vertical foot of wall becomes excessive, and usually some other type of wall will be found more economical for the larger reservoirs.

## SOME POSSIBILITIES OF PRESSURE FILTERS.*

One kind of service for which the pressure filter is particularly well adapted is the treatment of water exclusively for industrial use, where the elimination of bacteria is not essential and where in some instances even complete clarification is not necessary. For this service the pressure filter in its usual form proves cheap and suitable. Good washing is of full importance, and a combined settling and coagulating basin may be a necessity in the case of a muddy water supply, but precise rate control and recording devices are not so important and direct service to the distribution system, allowing demand to control the rate of filtration, is often entirely satisfactory.

The cost of a thoroughly up-to-date installation of 1,000,000 gal. daily capacity would be about as follows:

| | |
|---|---|
| Two 8-ft. x 20-ft. filters equipped in the ordinary way, including erection and foundations | $ 5,000 |
| Controlling devices, air wash equipment and general improvements | 1,300 |
| Settling basin of two hours' capacity | 3,500 |
| Low-lift pumps | 1,200 |
| Superstructure | 1,500 |
| Total | $12,500 |

A first-class gravity plant of the same capacity costs in the neighborhood of $20,000. For large plants the cost of construction per million gallons daily capacity would be about $12,500 for gravity filters and about $9,000 for pressure filters. These figures are not offered as being exact and there will, of course, be considerable variation, depending upon the character of the site and other conditions attending construction, and upon prices of labor and materials, but they will serve to indicate in a general way the relative cost of installation.

The cost of operation of pressure filters should be about the same as is the case with gravity filters, except that the cost of pumping may be a little greater, on account of the greater head utilized in the filter. The cost of upkeep will be a little higher for pressure filters, owing to the greater amount of steel work to be kept painted. Depreciation will also be a little more rapid, but the fact that certain pressure filters are still in use after twenty-five to thirty years of service shows this item to be almost insignificant.

The conclusions of the writer, summarized briefly, are as follows: (1) The pressure filter, as thus far constructed, is in some instances a very inferior means of purifying water, hygienically, and in other cases an excellent means, but on the average it is not entirely reliable. (2) There are no great obstacles in the way of developing it to the point of equality with the best gravity filters as regards efficiency and reliability, for any capacity and for most waters. (3) It is better adapted to the treatment of some waters than the gravity filter. (4) It is especially suited to very small water supplies and to the clarification of water for industrial uses. (5) The cost of construction of the highly developed pressure filter is materially less than that of the gravity filter, and low enough to more than offset a somewhat greater expense for operation and maintenance. (6) The improved pressure filter deserves the most careful consideration by sanitary engineers, filter manufacturers and public health officials.

## ENGINEERING WATER SUPPLY BY GAS ENGINE DRIVEN PUMP.

(Contributed.)

The water department of a central Pennsylvania town was compelled by a severe drouth to shut off the water supply from all the factories in the district it served, and the supply even then was too scant to provide for the electric light and power plant on which the entire town was dependent. During this dry period an emergency supply was secured for over a month by placing a gasoline-engine driven pump on the bank of a stream about a mile away and conducting the discharge through a 1½-in. pipe. Night and day operation of the

Emergency Gasoline Engine Water Supply.

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*Extract from a paper by Harold E. Stevens in the Journal of the American Water Works Association for June, 1916.

pump supplied the power plant (300 kw. capacity) and also a large machine shop and foundry, all of which would otherwise have had to shut down.

The pumping engine as illustrated was a 3 h.p. unit with 4-in. pump (5-in stroke) having a capacity of over 38,000 gal. in 24 hours. The two pipes leading down in front to the water are the suction and the overflow. The latter carried all surplus, which escaped through a relief valve, back to the stream. The considerable quantity of water shown coming back through this overflow indicated that the pump had plenty of surplus capacity.

A gang of four men with a team of horses in less than a day installed the entire outfit, which included a mile of the delivery pipe, laid over the ground on the most convenient route to the power house.

The pumping engine was a standard outfit of the type made by Domestic Engine & Pump Co., Shippensburg, Pa., for the use of contractors in supplying water for contract jobs. It is said that this method of pumping offers far greater capacity than the ordinary method of hauling in tank wagons, is very much lower in cost, and is equally valuable to manufacturers for temporary or permanent water supply, and to farmers and orchardists for irrigating.

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## PUMPING WATER FOR IRRIGATION.

Contributed by Louis Schmeer, Irrigation Engineer, Colton, Cal.

(Continued from May 31, 1916.)

**The Theory of the Flow of Wells.**—In discussions on this subject the notation used is as follows:

R = the semi-diameter of a well.

L = the semi-diameter of the circular part of the waterbearing stratum tributary to the well (Fig. 1).

H = the elevation of the watertable in the stratum at the distance L from the center of the well, reckoned from a horizontal passing through the lower edge of the waterbearing stratum at the well, providing the stratum is entirely penetrated; otherwise reckoned from a horizontal passing through the floor of the well; or, the elevation of the water in the well above the same datum when pumping commences.

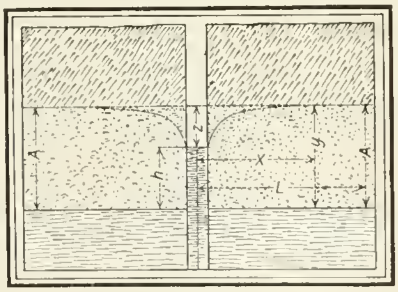

Fig. 1.

h = the elevation of the water in the well above the same datum when Q cubic feet per day are being pumped.

Z = H — h = the depression of the surface of the water in the well when Q cubic feet per day are being pumped.

If we conceive a circular section of the waterbearing stratum surrounding the well to have an elevation y above datum at the distance X from the center of the well the circumference of the circle is equal to $2\pi X$ and for vertical flow, since $2\pi X y$ is the area of percolation.

$$Q = K 2 \pi X y.$$

At the distance R from the center of the well the area of percolation is equal to $2\pi R h$ and for vertical flow

$$Q = K 2 \pi R h.$$

The slope between the elevations y and h is given by

$$\frac{y - h}{X - R}$$

and the equation for the surface of the watertable in the region surrounding the well may consequently be written,

$$\frac{dy - dh}{dx - dR} = \frac{Q}{2\pi} \frac{1}{x y}$$

which gives, for $X = R$, $y = h$
$X = L$, $y = H$

$$\frac{y^2 - h^2}{2} = \frac{Q}{K 2 \pi} \log X - \log R;$$

$$\frac{H^2 - h^2}{2} = \frac{Q}{K 2 \pi} \log L - \text{Log } R.$$

Hence the flow in cubic feet per day

$$Q = \frac{K 2 \pi \frac{H^2 - h^2}{2}}{\log L - \log R}$$

in which the log. is the Naperian.

This is known as Dupuit's formula. It may be written:

$$Q = \frac{K 2 \pi \left(\frac{H + h}{2}\right) Z}{\log L - \log R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In practice it has been found that for values of Z less than ¾ H the yield is very near proportional to H Z, so that

$$Q = \frac{K 2 \pi \quad H Z}{\log L - \log R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Consequently, from formula (2),

(1) The yield is proportional to the thickness of the saturated part of the stratum as far as penetrated by the well;

(2) The yield is proportional to the drawdown, or the depression of the surface of the water in the well during continuous pumping.

The value of H is not increased by any distance, the well may penetrate into an impervious stratum occurring below the water bearing layer.

Should however the surface of the water in the well ascend above the stratum in which it originates the flow will be increased and the well is said to have a head. This rise usually takes place when the waterbearing stratum rests on a slope and is capped by an impervious layer; it may, however, occur when an impervious cover is absent. In this case it is due to greater velocities of flow in the lower zones of the stratum, occasioned by a diminution of the viscosity of the water under the greater pressure. Suppose the water ascends to an elevation p feet above the porous stratum and this is penetrated to a depth of H ft. by the well. The yield will then be equal to

$$Q = \frac{K 2 \pi H Z}{\log L - \log R} \frac{(H + p)^2}{H^2} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

In case the water rises above the surface of the ground the flow is artesian.

Let Y = the elevation above the surface of the ground to which water will ascend in a tube, then,

$$Q = \frac{K 2 \pi H Y}{\log L - \log R} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

The difficulty in finding a value for the distance L has occasioned much discussion. Dupuit and some of his followers considered it to be a variable; the best of the contemporary authorities, however, assume it to be a constant. Slichter assumes L = 600 ft.; some European hydrologists 200 meters.

The results of numerous tests of wells lead the contributor to believe that $\log \frac{L}{R} = 2\pi$, both for English and metric measure. This gives L = 535 ft. = 163 meters.

Hence in case R = unity = 1 ft., the flow is equal to

$$Q = \frac{K 2 \pi H Z}{\log 535} = K H Z \quad \ldots\ldots\ldots\ldots\ldots (5)$$

For values of R less or greater than unity, the power of the semi-diameter to which the flow is proportional is found by putting

$$X = \frac{\frac{6.28}{\log 6.28 - \log R_1} - \frac{6.28}{\log 6.28 - \log R_0}}{\log R_1 - \log R_0}$$

which gives for values of R between 1 in. and 1 ft. $X = \frac{1}{8}$; for values of R between 1 and 10 ft. $X = \frac{1}{5}$; very near. Hence for wells up to 2 ft. in diameter

$$Q = K H Z \sqrt[8]{R} \, (0.70 - 0.03 \, T \, C^\circ) \quad \ldots\ldots\ldots (6);$$

for the same with a head p above the waterbearing stratum

$$Q = K H Z \sqrt[8]{R} \left( \frac{H + p}{H} \right)^2 (0.70 - 0.03\ T\ C^\circ) \ldots (7);$$

for the same with an artesian head Y above the outlet

$$Q = K H Y \sqrt[5]{R}\ (0.70 + 0.03\ T\ C^\circ) \ \ldots\ldots\ldots\ldots (8)$$

in all of which $\sqrt[5]{R}$ is substituted for $\sqrt[8]{R}$ in case the diameter of the well exceeds 2 ft. Should the well not entirely penetrate the water bearing stratum there is some influx through the bottom and the discharge will be

$$Q = K H Z \sqrt[8]{R} + 2 \pi K H R\ (0.70 - 0.03\ T\ C^\circ \ \ldots (9)$$

From this it is seen, that the discharge of an infiltration well, that is, one lined with a watertight wall or casing and into which the water filters through the bottom only is given by

$$Q = 2 \pi K H R\ (0.70 + 0.03\ T\ C^\circ) \ \ldots\ldots\ldots\ldots (10)$$

Values of $\sqrt[8]{R}$ and $\sqrt[5]{R}$ for the most common semidiameters are found in Table III.

TABLE III.

| D. in inches. | $\sqrt[8]{R}$. | D. in inches. | $\sqrt[8]{R}$. | D. in feet. | $\sqrt[5]{R}$. | D. in feet. | $\sqrt[5]{R}$. |
|---|---|---|---|---|---|---|---|
| 2 | 0.755 | 14 | 0.935 | 4 | 1.149 | 16 | 1.516 |
| 4 | 0.800 | 16 | 0.950 | 6 | 1.246 | 18 | 1.552 |
| 6 | 0.841 | 18 | 0.965 | 8 | 1.320 | 20 | 1.585 |
| 8 | 0.871 | 20 | 0.977 | 10 | 1.380 | 24 | 1.644 |
| 10 | 0.896 | 22 | 0.989 | 12 | 1.431 | 28 | 1.695 |
| 12 | 0.917 | 24 | 1.000 | 14 | 1.475 | 32 | 1.741 |

For a drawdown of one foot the yield of a two-foot well penetrating a waterbearing stratum to a depth of 10 ft. is about as follows, T C° = 10°.

TABLE IV.

| Material. | D in millimeters. | K. | Q in cu. ft. per day. |
|---|---|---|---|
| Fine gravel ............... | 1 -2 | 600 -2,400 | 6,000-24,000 |
| Coarse sand ............... | 0.5 -0.75 | 150 - 337.5 | 1,500- 3,375 |
| Medium sand ............... | 0.25-0.375 | 37.5- 84.4 | 375- 844 |
| Fine sand ............... | 0.10-0.1875 | 6 - 21.1 | 60- 211 |
| Very fine sand............... | 0.05-0.075 | 1 5- 3.37 | 15- 33.7 |
| Potsdam or Dakota sandstone ............... | 0.10 | 9.5 | 95 |

In case a well passes through a stratum consisting of successive zones of unequal transmission capacity the discharge will be equal to:

$$Q = (h_1 K_1 + h_2 k_2 + hn\ kn)\ Z \sqrt[8]{R}\ (0.70 + 0.03\ T\ C^\circ.\ (11)$$

in which $h_1$ is the depth of the upper zone and $K_1$ the transmission capacity of the material within it, $h_2$ the depth of the second zone and $K_2$ the corresponding transmission constant, etc., etc.

In Part II, Report of U. S. Geol. Survey of 1898, Prof. King gives data relating to a test of a well penetrating into a stratum of Potsdam sandstone consisting of layers of unequal transmission capacity which strikingly illustrate the most noteworthy principles involved in the flow of wells.

The test well was 6 in. in diameter and penetrated the stratum to a depth of 20.36 ft. without however entirely passing through. At the commencement of pumping, the surface of the water in the well stood 26.32 ft. above the surface of the sandstone, the entire depth of the water being 47.16 ft.

The depths of the different zones of the sandstone, the effective diameters, the porosity percentages and the corresponding values of $h_1 K_1 - h_2 K_2$, etc., as computed from the formula K = 22,464 P 3.3 D 2 were as follows:

| Thickness of zone in feet. | Effective diameter of sand grains in m.m. | Porosity percentage. | Value of h k. |
|---|---|---|---|
| 2.5 | 0.05612 | 0.338 | 4.93 |
| 4.67 | 0 07817 | 0.3399 | 18.05 |
| 6.67 | 0.1214 | 0.3122 | 48.52 |
| 7.00 | 0.2006 | 0.3040 | 124.50 |
| 20.84 | | | 196.00 |

Hence the average value of K is equal to $\frac{196}{20.84} = 9.4$.

For H + p = 47.16 and H = 20.84 the value of $\left( \frac{H + p}{H} \right)^2$ is equal to 5.12. For a diameter of 6 in. the value of $\sqrt[8]{R}$ is 0.841. Since the well does not penetrate through the whole of the stratum the infiltration through the bottom amounts to Q = 6.28 × 196 × 0.25 = 307 cu. ft. per day.

Inserting these values we have the equation

$$Q = (196 \times 0.841 \times 5.12)\ Z + 307.$$

The following table gives the measured and the computed flow for the several values of Z:

| Drawdown in feet. Z. | Measured flow. Cu. ft. per day. | Computed flow. Cu. ft. per day. |
|---|---|---|
| 1.333 | 1,440 | 1,430 |
| 2.208 | 2,266 | 2,168 |
| 2.917 | 2,874 | 2,766 |
| 3.333 | 3,055 | 3,113 |

## II.—The Influence and the Spacing of Wells.

The ideal well is one so situated that the waterbearing stratum ascends in every direction from its center. From formula (5) it is seen that the radius of influence of such a well is given by $535 \sqrt[8]{R}$ or $535 \sqrt[5]{R}$, as the case may be.

In practice the waterbearing stratum usually only ascends in one direction from the center of the well and the actual radius of influence is a quantity varying in every direction. Its value in any direction depends on the normal velocity of flow in the stratum, or on the slope. The curve of radii of influence of a well on a slope resembles the section of a pear, the stem pointing up stream. The normal movement of the water in the stratum is proportional to the slope of the watertable into half the depth of the stratum. If the stratum is penetrated by a well the dividing line between the movement towards the boring and that downstream is evidently given by the points where the velocities of flow are equal.

Let s = the slope of the watertable;
h = the depth of the stratum;
z = the drawdown in the well during pumping;
L = the distance from the well where the velocities are equal; then, for equal velocities

$$\frac{K H s}{2 P} = \frac{K H z}{2 P L\ (\log L - \log R)},$$

which gives

$$L = \frac{Z}{s\ (\log L - \log R)}.$$

The following table gives values of L for a 2 ft. well computed from this formula. All these values are to be multiplied by $\sqrt[8]{R}$ or $\sqrt[5]{R}$ for any other diameter of the well.

TABLE V.—VALUES OF L FOR A WELL 2 FT. IN DIAMETER.
Radii of Influence.

| S = slope of water table. | Z = drawdown in feet. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2.5 | 5 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | 25 | 30 |
| 00004 | 3110 | 7050 | 13170 | 19030 | 24700 | 30280 | 35760 | 41190 | 46520 | 57100 | 67400 |
| 00006 | 2168 | 4900 | 9100 | 13170 | 17100 | 20940 | 24700 | 28400 | 32100 | 39400 | 46500 |
| 00008 | 1680 | 3790 | 7050 | 10160 | 13170 | 16100 | 19000 | 21880 | 24700 | 30300 | 35760 |
| 0001 | 1380 | 3110 | 5770 | 8310 | 10770 | 13170 | 15540 | 17870 | 20170 | 24700 | 29180 |
| 0002 | 754 | 1680 | 3110 | 4460 | 5770 | 7050 | 8310 | 9540 | 10770 | 13170 | 15540 |
| 0004 | 416 | 916 | 1680 | 2400 | 3110 | 3790 | 4460 | 5120 | 5770 | 7050 | 8310 |
| 0006 | 293 | 644 | 1178 | 1680 | 2168 | 2640 | 3110 | 3560 | 4010 | 4900 | 5770 |
| 0008 | 230 | 502 | 916 | 1300 | 1680 | 2040 | 2400 | 2760 | 3110 | 3790 | 4460 |
| 001 | 191 | 416 | 754 | 1074 | 1380 | 1680 | 1970 | 2260 | 2550 | 3110 | 3650 |
| 0015 | 136 | 293 | 531 | 754 | 970 | 1178 | 1380 | 1580 | 1780 | 2168 | 2550 |
| 0020 | 107 | 220 | 416 | 588 | 754 | 916 | 1074 | 1229 | 1380 | 1680 | 1970 |
| 0030 | 77 | 163 | 293 | 416 | 531 | 644 | 754 | 861 | 970 | 1178 | 1380 |
| 004 | 60 | 128 | 230 | 324 | 416 | 502 | 588 | 670 | 754 | 916 | 1074 |
| 006 | 44 | 92 | 163 | 230 | 293 | 354 | 416 | 473 | 530 | 644 | 754 |
| 008 | 35 | 72 | 128 | 180 | 230 | 277 | 324 | 369 | 416 | 502 | 588 |
| 01 | 29 | 62 | 107 | 149 | 191 | 230 | 268 | 305 | 342 | 416 | 485 |
| 02 | 14 | 35 | 62 | 84 | 107 | 128 | 149 | 168 | 191 | 230 | 268 |

The frequent occurrence of the figure 3110 and others in Table V indicates that the radius of influence remains constant whenever Z and s are multiplied equal times. The tabular radii of influence are those at right angles to the greatest slope or to the normal movement of the water. Between two wells they indicate the point of no depression, for a single well the point where the separation between the normal movement down the slope and that towards the well takes place. Pointing up stream the radius of influence is much longer, downstream much shorter than the tabular radius.

Suppose it is desired to intercept the underground flow passing down a valley having a slope of 7.92 ft. per mile. It is proposed to sink a row of 14-in. wells each having a discharge of 2.5 second feet. A testwell sunk to a depth of 30 ft. below the plane of saturation indicated a drawdown of 20 ft. for the desired discharge. For this drawdown and the given slope the table gives L = 1,780 ft.

Hence for a total non-interference the distance between two wells will be 2 × 1,780 = 3,560 ft. The question arises: Does all the water coming down the slope in a strip of the stratum 2 L ft. wide enter the well? If our formulas are correct this is evidently not the case.

For the given slope and depth of the stratum the normal flow through a strip 2 L = 3,560 ft. wide is equal to $Q = \frac{K \times 30^2 \times 7.92 \times 3{,}560}{2 \times 5{,}280} = K \times 2{,}403$ cu. ft. per day.

The flow into a 14-in. well for the given drawdown is equal to $Q = K \times 30 \times 20 \times 0.935 = K \times 561$ cu. ft. per day.

The flow through the strip is consequently $\frac{2403}{561} = 4.28$ times the flow into a 14-in. well and a row of wells $\frac{3560}{4.28} = 830$ ft. apart will probably very near drain the stratum of all its water. For a complete drawdown, equal to the depth of the stratum, the spacing would be 1,245 ft.

From this it follows, that the spacing in general, for any drawndown Z and any depth of the stratum H penetrated by the well is given by

$$L = \frac{2 \sqrt{R Z}}{s H},$$

and for a complete drawdown simply by

$$L = \frac{2 \sqrt{R}}{s}$$

Suppose it is desired to intercept the seepage from a river by means of a row of wells, situated at a distance of 200 ft. from the shore. The slope of the watertable at the normal stage of the river is one in five hundred and the rise of the river in times of flood is 5 ft. Between the wells and the river this gives a high-water slope of $\frac{5.4}{200} = 0.027$. Hence the spacing of the tabular wells for a complete drawdown,

$$L = \frac{2 \sqrt{R}}{0.027} = 74 \sqrt{R} \text{ ft.}$$

In case the slope of the watertable is not known or can not be easily ascertained the most reliable method of finding the proper distance between wells consists in first finding the normal quantity of flow in the stratum per ft. of its width by actual measurement of the velocity and then sinking a test well and noting its output for a complete drawdown. This output, divided by the flow in a strip of the stratum one foot wide gives the desired distance for a complete drainage of the stratum.

The normal velocity of flow in a stratum may be determined either by the electrical method perfected by Prof. Slichter or by the so-called Fluorescin method. The latter method is the simpler and gives fairly good results when applied to flow in strata composed of coarse sand or gravel.

Fluorescin is one of the coal tar dyes and imparts to water in which it is dissolved even in very minute quantities, a peculiar greenish tint; the presence of 0.025 part per million may be detected with the unaided eye. In practice the dye is used in a solution of 30 per cent or 2.5 pounds per gallon of water. The quantity actually used in one experiment varies between 0.5 and 5 pounds, depending on the depth of the stratum and the degree of accuracy desired. The greater the distance chosen through which the dye is to travel the greater the probability to arrive at accurate results. Suppose the stratum is 30 ft. deep and it is desired to find the time it takes the dye to travel a distance of 50 ft. Then the probable area of dissemination of the dye would be $50^2 \times 3.14 = 31{,}400$ sq. ft. and the volume of a cylinder 30 ft. deep 9,420,000 cu. ft. For a porosity of 30 per cent the cylinder will contain 3,140,000 cu. ft. or 196,000,000 pounds of water. If a tint is to be visible to the unaided eye $196 \times 0.025 = 4.84$ pounds of the dye may therefore be estimated to be necessary. By the aid of a fluoroscope it is possible to detect the presence of the dye in a solution of 0.0005 part per million and much smaller quantities may therefore be used. In the case above a solution of 0.0025 per million would do, amounting to $196 \times 0.0025 = 0.485$ pounds.

The fluoroscope consists of a tube or a collection of tubes each about 38 in. long and 0.6 in. in diameter, made of pure, white glass. At the bottom the tubes are closed with stoppers well blackened with powdered plumbago. When a tube is filled with the water to be examined a greenish reflection or shade on the blackened stopper will indicate the presence of the dye.

In the locality where the velocity of flow is to be determined, a row of 1½ or 2-in. perforated gas pipes with well points is driven into the stratum, preferably down to an impervious layer, in the direction of the greatest slope and spaced 5-10 ft. apart. The 30 per cent fluorescin solution is poured into the upper pipe and the progress of the dye downstream ascertained at intervals of 5-10 hours by taking samples of water from the pipes.

A method occasionally followed but lacking precision consists in driving a test well and a row of 1½—2-in. perforated gas pipes with well points, spaced 50-100 ft. apart in a line across the valley. When the pump is drawing water from the test well the depression of the surface in the different pipes for each output and drawdown is noted and the wells spaced accordingly.

(To be continued.)

## A MOTOR TRUCK TESTING CHICAGO WATER MAINS.

Contributed by Frank C. Perkins, Buffalo, N. Y.

The accompanying illustration shows a motor truck for testing water mains installed by the city of Chicago, Department of Public Works. The apparatus consists of a White ¾-ton truck equipped with a three-stage centrifugal pump, driven from the power transmission. There was a careful test of the apparatus made by the Pipe Extension Department and the results obtained were very satisfactory, it being found that the motor would pump 140 gal. of water per minute and maintain a pressure of 140 lb. at the pump with little effort. Runs were made with the transmission in second speed and in direct and the engine was easily able to meet the requirements in each case.

Special Motor Truck for Testing Water Mains.

The work done by the truck is explained by Mr. Robert Winehardt, superintendent of the Fire Department shops, as follows: This machine is used by the water Department to test jobs done by contractors in the laying of water pipes. After the contract is given out and the pipe laid by the contractor, it is tested before payment is made. As a rule the mains are filled with the pump. The testers then go to the nearest water plug and attach a 2½-in. fire hose to the motor apparatus. The water is run into the centrifugal pump at about 30 lb. pressure (city pressure), the centrifugal pump then lifts the pressure to 130 lb. and sends it into the main. If there is no air in the pipe, it is a simple job, and after running at this pressure for ten or fifteen minutes, the valve is closed and if the pressure stays or holds, it shows there is no leak in the pipe, and no broken pipe. The job is then O.K.'d and paid for.

## EXPERIENCE IN FREEZING OF A SUBAQUEOUS MAIN LAID IN SALT WATER AND USE OF ELECTRICITY TO THAW OUT THE MAIN.*

In February, 1912, New York and vicinity experienced a very cold spell, which commenced on Feb. 3, and continued until Feb. 15. The severest cold was experienced from 11 p. m. on Feb. 9 to 11 a. m. on Feb. 13, the temperature of the first 36 hours of this period ranging from 14° F. to minus 1° F. During the night of the 11th-12th, the temperature averaged about 13° F. At 9 a. m. on Feb. 12, word was received at the South Bronx Repair Co.'s headquarters that there was lack of pressure at North Brothers Island. This island is located about 1,800 ft. from the Borough of the Bronx shore, opposite 132d St. At that time the island was supplied with water by a 6-in. main, 1,760 ft. in length, laid in 1888, the general depth of the water being 70 ft. This line was exposed at low tide for a distance of about 150 ft. from the North Brothers Island shore. An auxiliary line, 12-in. in diameter and 29,700 ft. long, was laid in 1906, from Riker's Island to North Brothers Island, Riker's Island being supplied from the mainland by a 12-in. main. The average depth of water in which the 12-in. main was laid was 30 ft. When it was found that the water pressure was reducing, effort was made to increase the flow by opening a fire hydrant and by operating a pump on the island, that was connected to the water main. The evidence at the time pointed to trouble existing both in the 12-in. main and in the 6-in. main. On the morning of Feb. 13, the supply to the island was entirely stopped, and it was not resumed until March 12. At the time of stoppage there had been an extremely low tide and the 6-in. pipe line on the North Brothers Island shore had no cover except rip-rap.

The first trouble was experienced a day and a half after the beginning of the extreme cold spell, and the final stoppage of the main was two and a half days thereafter. The nights during this period were clear, while the days were partially cloudy. The wind was from the north and northwest, with a maximum velocity of 22 miles an hour. The temperature of the river was not taken at this time, but a week later, the weather in the interval remaining at about freezing point. The temperature in the river at a depth of 50 ft. was found to be 29° and 32° on the surface. It is probable that the river water was at a lower temperature than 29° when the main was frozen. The weather conditions were ideal for radiation of heat from the main. The temperature of water in the pipe, before it entered the river, was about 34°, this being the recorded temperature of water from the same source that had traveled an equal distance underground. On the main shore end of the pipe, frost was in the ground to a depth of 39 in., which was 3 in. below the bottom of the pipe.

Effort was made to thaw out the main by building fires around the exposed portion, and using steam hose. A tap placed on the main showed that the main was frozen solid below tide level. As all efforts to thaw the main by ordinary means failed, and as there were about 500 people on the island, mainly patients in a hospital, who could only be served with water transported on boats from the mainland, arrangements were made with the Edison Electric Co. to thaw out the main, using electricity. This company started work on March 6, and on the morning of March 7, a current of about 800 amperes at 200 volts was passed through the main, using four 100 kilowatt transformers to step the current from 2,000 volts down to 200. During that evening the current was increased to 1,000 amperes, on the 8th to 1,300 amperes, and on the morning of the 9th, to 1,500 amperes and 400 volts, two more 100 kilowatt transformers having been installed. At noon on the 10th, the current was increased to 1,800 amperes at 368 volts. As the ice failed to melt, an experiment was tried, a length of pipe being packed solid with ice, closed tight at both ends, and let down to the bottom of the river, and the same current passed through it as was passed through the main. After 12 hours the ice was found to be entirely melted. The current was continued until 6:20 a. m. on Tuesday, March 12, and without any previous warning the water started to flow from the mainland end of the pipe. During the time the current was on, 1,000 h.p. had been used, it being estimated that 36 times as much heat had been generated to melt the ice in the North Brothers Island main as would have been required to melt the same quantity of ice on land. The rapid transmission of the heat from the pipe to the cold water flowing over the pipe was the cause for failure of this method to thaw out the pipe. On March 12, the date when water started to flow, the temperature of the water was 32°. On the same day the pipe line from North Brothers Island to Riker's Island thawed out, from natural causes.

On March 10, it had been clear throughout the day and night and the temperature had reached 86° in the sun, the maximum in the shade being 41°, the minimum 33°, with an average of 32°. Under such conditions there would be a very material absorption by the water main of heat, through radiation, and with the temperature of the river water up to the freezing point it is possible that the electric current had little effect on the thawing of the main, although the heat generated by the current was noticeable on the shore ends of the pipe. There is no clear indication of the effectiveness of the electric current thawing the main under the conditions cited.

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*Extract from a paper by Wm. W. Brush before the Four States' Section, American Water Works Association.

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## SOME PLANT AND METHODS FOR LARGE SIZE BRICK SEWER CONSTRUCTION IN CHICAGO.

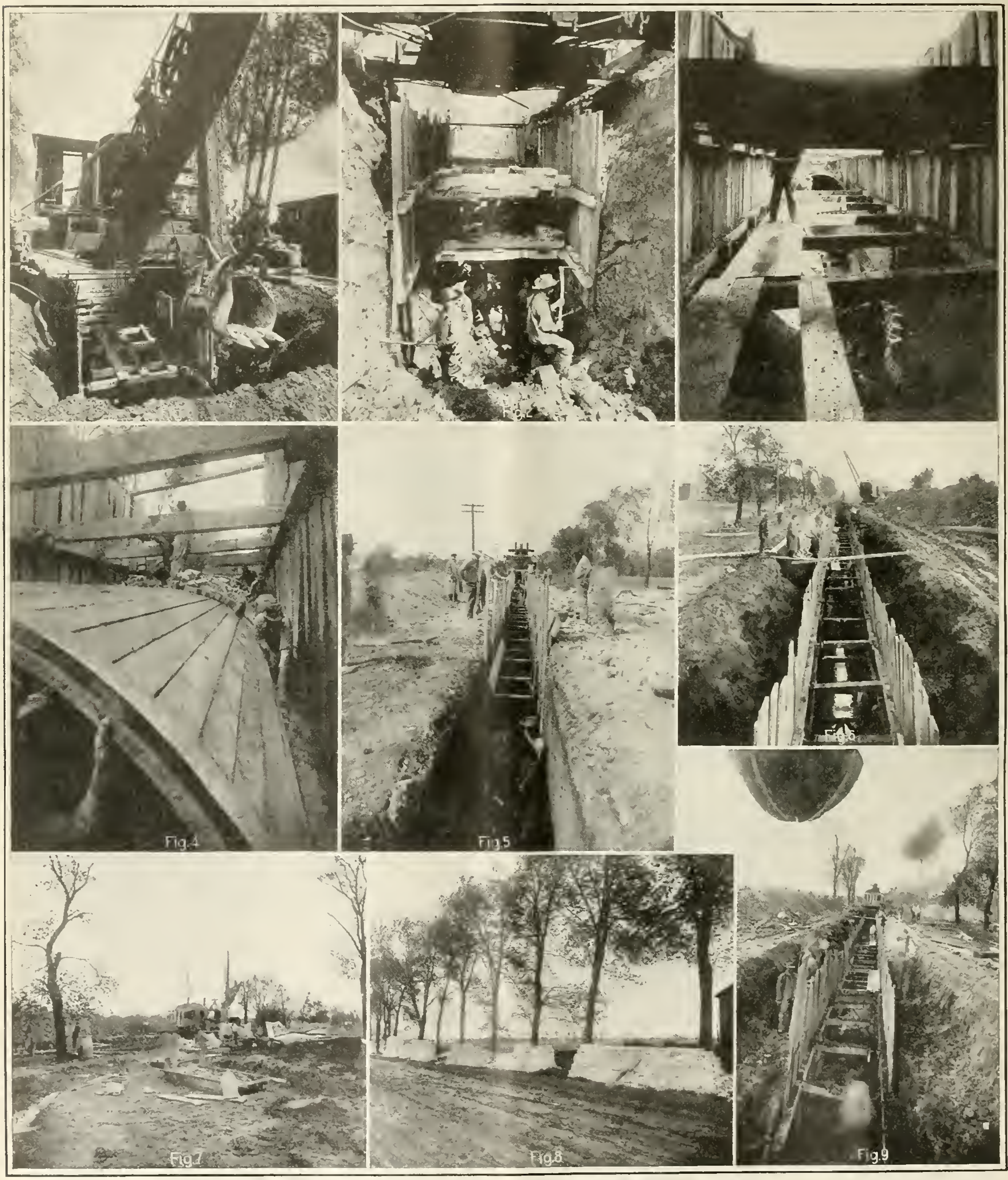
The 14-mile sewer system known as the Argyle St. system now under construction in Chicago is one of the largest single pieces of sewer work to be undertaken recently in the United States. When completed this system will furnish sewerage to the territory now comprised by the communities of Jefferson Park, Norwood Park and Edison Park, lying north of Wilson Ave. and south of the Chicago River. The work is being done by the H. J. McNichols Co., as contractors, under the direction of the Board of Local Improvements, Chicago, with Mr. C. D. Hill as chief engineer and Mr. Geo. C. D. Lenth as assistant chief engineer of sewers.

### General Purpose and Character.

Edison Park for some years has had a sewer system which terminated in a ditch at the city limits at 72d Ave., just north of Ibsen Ave. From this point the sewage flowed in an open ditch across country to the village of Niles into the north branch of the Chicago River. The Norwood Park sewer system terminated in a ditch located at the southerly side of the Chicago & Northwestern Ry. tracks near Ardmore Ave. and thence flowed across the country about 1½ miles to the Chicago River. These open ditches containing sewage were a source of a good deal of complaint from the people living and driving through this section of the city. In addition, the village of Edison Park, before annexation, had been served with a notice by the village of Niles to alleviate the nuisance and to stop the flow of sewage through this village. This fact brought about the annexation of Edison Park to Chicago. This newly annexed territory will be served by the new sewer system.

The area of the territory drained by this sewer system is approximately 5,000 acres. The length of the system is 14 miles and it varies in size from a 2½-ft. brick sewer to a 9-ft. brick sewer. Several special features in connection with the system are of interest. These include the overflow chambers at Forest Glen Ave. and Catalpa Ave. and at Foster Ave. and Tripp Ave. The sewer discharging into the chamber has an internal diameter of 9 ft. and at these points it is enlarged to an internal diameter of 10 ft. Across the chamber in the plan in the shape of a Z there is a weir. On the upstream side of the weir is a channel by means of which the dry weather flow is diverted to a dry weather flow sewer leading from the overflow chamber. These connected pipes were computed as acting as short tubes, and in one case the internal diameter is 24 ins. and in the other it is 27 in.

The crest of the weir in each case is 3 ft. above the bottom of the chamber. On the downstream side of the weir the sewer decreases in size by means of 16-ft. sections to the proper size of the outlet sewer, which in the case of the Forest Glen sewer is 6 ft., and in the case of the Foster Ave. sewer is 6½ ft. The paramount principle in this design has been to eliminate as far as possible all pollution from the North Branch of the Chicago River. The dry weather flow will in all cases, except in the case of excessive storms, flow through the connecting pipes into the overflow chamber and in the dry weather overflow chambers, eventually emptying in the North Shore Channel of the Sanitary District located at Argyle St. and the Sanitary Canal.



CONSTRUCTION VIEWS ON LARGE SEWER WORK IN NORWOOD PARK DISTRICT OF CHICAGO.
Sewers range from 3 ft. to 9 ft. in diameter and are brick laid in 1:2 natural cement mortar.

### Division of the Work.

The work is divided into two sections. The first section comprises the portion of the system between the outfall and Argyle St. and the overflow chamber at Forset Glen Ave. and Catalpa Ave. Section 1 covers the construction of sewers in the following streets and avenues, the approximate lengths, diameters and average depths being as indicated:

| Laid in. | Length, ft. | Int. diameter, ft. | Av. depth, ft. |
|---|---|---|---|
| Argyle Street | 2,630 | *6 | 18 |
| Argyle Street | 710 | *6 | 13½ |
| Argyle Street | 3,360 | *5½ | 18½ |
| Argyle Street | 1,670 | *5 | 21½ |
| Tripp Avenue | 1,330 | *5 | 21½ |
| Foster Avenue | 940 | †6½ | 9 |
| Foster Avenue | 3,690 | †9 | 21 |
| Foster Avenue | 1,030 | †7¾ | 22 |
| Foster Avenue | 2,980 | *5½ | 14 |
| Foster Avenue | 1,140 | *5 | 15 |
| Milwaukee Avenue | 170 | *5 | 19 |
| Milwaukee Avenue | 1,100 | *3 | 15½ |
| Norwood Park Avenue | 910 | *5 | 16 |
| Foster Avenue | 2,440 | *5 | 16 |
| North Cicero Avenue | 2,660 | *4 | 18 |
| North Cicero Avenue | 680 | *3 | 16 |
| North Cicero Avenue | 680 | 2½ | 15½ |
| North Cicero Avenue | 680 | *2 | 12 |
| Maynard Avenue | 980 | *5 | 18 |
| Elston Avenue | 680 | *4½ | 21½ |
| Elston Avenue | 400 | 1 | 12½ |
| North Lawler Avenue | 1,290 | *4½ | 18½ |
| North Catalpa Avenue | 450 | *4½ | 18½ |

*2-ring. †3-ring.

The other work in Section 1 includes 121 manholes, 286 standard catch basins, 2 large catch basins, and a concrete bulkhead at Foster Ave. and Chicago River, and a similar structure at Argyle St. and the North Shore Channel. There also will be the special brick overflow at Foster Ave. and Tripp Ave.

Section 2 covers the portion of the sewer lying westerly of the Forest Glen outfall. It includes the construction of sewers in the following streets:

| Laid in. | Length, ft. | Int. diameter, ft. | Av. depth, ft. |
|---|---|---|---|
| Forest Glen Avenue | 1,430 | *6 | 22 |
| Forest Glen Avenue | 1,100 | 1 | 12 |
| N. Leclaire Avenue | 950 | †9 | 17 |
| Elston Avenue | 2,130 | †9 | 15 |
| Lynch Avenue | 200 | †8½ | 14 |
| Catalpa Avenue | 3,060 | †8½ | 16½ |
| Milwaukee Avenue | 850 | †8¼ | 22 |
| Bryn Mawr Avenue | 1,040 | †8¼ | 21½ |
| Bryn Mawr Avenue | 1,160 | †8 | 21 |
| Norwood Park Avenue | 1,850 | †8 | 21½ |
| Norwood Park Avenue | 1,340 | *4 | 17½ |
| Nagle Avenue | 2,130 | †6½ | 19 |
| Naples Avenue | 1,290 | *6 | 16½ |
| Raven Street | 100 | *6 | 15½ |
| Natoma Avenue | 1,340 | *6 | 15 |
| Nieman Avenue | 1,770 | *4½ | 12 |
| Newark Avenue | 710 | *4½ | 12 |
| Imlay Avenue | 1,130 | *4½ | 14 |
| Isham Avenue | 1,080 | *4½ | 19 |
| Harlem Avenue | 2,140 | *4½ | 16½ |
| Harlem Avenue | 2,840 | *4 | 16 |
| Harlem Avenue | 1,520 | *3½ | 16 |
| Peterson Avenue | 850 | *2½ | 13 |
| Ibsen Avenue | 1,910 | *4 | 13½ |
| Olcott Avenue | 680 | *3½ | 13½ |
| Pratt Avenue | 220 | *3½ | 13½ |
| Oliphant Avenue | 1,000 | *3½ | 16½ |
| Ardmore Avenue | 1,460 | *3 | 13 |
| Newark Avenue | 660 | *3 | 14 |
| Maynard Avenue | 1,330 | *3½ | 19 |
| Maynard Avenue | 1,330 | *3 | 18½ |

*2-ring. †3-ring.

The other work in Section 2 includes 184 manholes, 342 standard catch basins, 8 large catch basins, two concrete bulkheads and the special brick overflow at Forest Glen Ave. and Catalpa Ave.

### Plant and Methods.

The plant and methods of construction employed are illustrated by the views Figs. 1 to 9. Figure 1 shows steam shovel excavation of a 9-ft. sewer trench 24 ft. deep. The shovel is a 45-ton Bucyrus, with 30-ft. boom, 40-ft. dipper handle and 1½ cu. yd. dipper. Two Daventake the spoil from the shovel to the rear for backfilltake the spoil from the shovel to the rear for backfilling. Another Bucyrus shovel used on this work has a 36-ft. boom and a 52-ft. dipper handle and operates a 2-cu. yd. bucket. Figure 2 shows the method of bracing and sheeting and the bottom trimmers at work, as will be noticed, almost directly underneath the shovel. The sheeting is built in 12-ft. sections close behind the trimmers. Figure 3 shows the bricklaying. The invert is first laid and then the arch, using special forms of the type shown by Fig. 4, which shows a 9-ft. sewer. The steel arch ribs are spaced 4 ft. apart and carry 2x6-in. x 16-ft. beveled lagging planks. Figure 5 shows one of the lateral sewers in a 16-ft. deep trench dug by a Parsons' trench excavator. Figure 6 is 21½-ft. trench for an 8-ft. sewer. It was dug by the larger Bucyrus shovel. In the distance is shown the Marion rotating crane with clamshell backfilling trench. A view of this same trench looking forward from the clamshell is shown by Fig. 9. Figure 7 shows the mortar mixing box used. For this work a 1:2 mortar of Utica natural cement and bank sand was used. About 44,000 barrels of Utica cement will be required for the work and it was furnished by the Thomas Connelly Co. of Chicago, Ill. The mortar mixing boxes are of steel 5x8 ft. and 1 ft. deep. The number of brick required is 24,000,000; they were furnished by the Illinois Brick Co. Figure 8 shows the brick piles along the work.

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## EXPERIENCE WITH COPPER SULPHATE AS AN ALGICIDE, ST. PAUL, MINNESOTA, WATER SUPPLY.*

Vadnais Lake is located 7 miles north of the city of St. Paul, and has for the most part high well drained shores. The lake is about 1¾ miles in length and ⅓ of a mile in width, covering about 358 acres. Its greatest depth is 57 ft., and the average depth for the entire lake is 27 ft. With the water at the ordinary level, the capacity of the lake is approximately 3,240,000,000 gal. The copper sulphate treatments were carried on by the Bureau of Water, Department of Public Utilities, of the city of St. Paul, for the purpose of destroying the micro-organisms which were objectionable in the city water supply.

While many organisms appeared at one time or another during the summer in the waters of Vadnais Lake, and disappeared, probably as a result of the copper treatment, many of them were not found in sufficiently large numbers to justify a statement concerning the exact effect of copper sulphate upon their existence. With several others, however, that were more common there can be no question as to the effect of copper sulphate. The following forms were found before one or more of the treatments in sufficient numbers to justify certain conclusions concerning the effects of the treatment as here given:

- Chlorophyceae. (Green Algae)
  - Spirogyra sp.
  - Eudorina elegans Ehr.
  - Pandorina morum (Mull.) Bory.
  - Pedias trum duplex Meyen.
  - Staurastrum sp.
- Diatomaceae. (Diatoms)
  - Stephanodiscus niagarae Ehr.
  - Synedra pulchella (Ralfs.) Kg.
  - Fragilaria capucina Desmaz.
  - Asterionella formosa Hass.
  - Cyclotella comta (Ehr.) Kg.
  - Melosira granulata (Ehr.) Ralfs.
- Cyanophyceae. (Bluegreen Algae)
  - Anabaena oscillarioides Bory.
  - Anabaena flos-aquae (Lyngb.) Breb.
  - Clathrocystis aeruginosa (Kuetzing) Henfrey.
  - Coelosphaerium Kuetzingianum Haegeli.
  - Aphanizomenon flos-aquae (Linn.) Ralfs.
  - Rivularia echinulata (Smith) Born. and Flah.
- Protozoa. (Animal Forms)
  - Ceratium longicorne Carter.
  - Dinobryon sertularia Ehr.
  - Uroglena volvox Ehr.
  - Vorticella communis Ehr.

From observations made on above mentioned forms, the following conclusions may be drawn:

(1) With conditions under which above treatments were made, the use of one part of copper sulphate in 12,000,000 parts of water is quite adequate for the elimination of Spirogyra, Cyclotella, and most of the Cyanophyceae. It will practically eliminate Melosira and the four protozoa here listed; for the other forms above mentioned it will bring about great reduction but may not eliminate them.

(2) The use of 1 part of copper sulphate in 10,000,000 parts of water is effective in practically eliminating all forms mentioned in above list, with the possible exception of Eudorina and Pandorina, and with the conditions under which the treatments were made this amount is entirely adequate for their suppression.

(3) With conditions under which above treatments were made, a treatment of one part of copper sulphate in 10,000,000 parts of water remains effective for about five weeks, after which time the organisms present, or many of them at least, seem to find conditions favorable for their growth and reproduction, and if the treatment is not repeated at this time they may increase again with remarkable rapidity.

(4) Where quiet shallow bays afford breeding places for numerous organisms, or where any one or more organisms become abundant in small or limited areas, local treatment, or the application of small quantities of copper sulphate to the particular spot where the trouble is originating, has been found very effective. If careful at-

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*Extract from a paper by N. L. Huff and Garret O. House, in Journal American Water Works Association for June, 1916.

tention is given to such areas, and accumulations of organisms prevented here, the number of general treatments necessary to keep the lake clean for the entire season may be lowered and the total cost of treatments materially reduced.

(5) For treatment of very shallow bays, flat muddy shores and small ponds the use of a hand pump such as is used for spraying trees is a practicable and economical means of distributing copper sulphate. In addition to spreading the solution in places inaccessible for a boat, this method has the advantage of leaving the water unroiled and gives the organism the full effect of the copper, much of which might otherwise be absorbed by mud and organic matter stirred up by a boat in such places.

## DATA AND DISCUSSION ON CAST IRON PIPE JOINT TESTS FOR THE SAN FRANCISCO HIGH PRESSURE FIRE SYSTEM.

Contributed by Aug. J. Bowie, Jr., Electrical, Mechanical and Hydraulic Engineer, Nevada Bank Bldg., San Francisco, Calif.

When it is considered that the leakage in the New York High Pressure Fire System is over 28 times as great per foot of joint as that of the San Francisco System under equivalent pressure conditions, considerable interest attaches to the methods whereby leakage has been minimized in the latter system. The construction of the San Francisco system also involved many interesting features incident to guarding against possible earthquake disturbances, and brought out excellent suggestions as to how leakage can be practically eliminated in any water system, whether of high or low pressure.

**Effects of Settlement.**—Extensive investigations of the effects of the earthquake of 1906 showed plainly that the worst damage occurred on filled land, and that structures on solid ground foundations suffered comparatively little. Some of the business district, and a considerable portion of the manufacturing district, is located on made ground, and in these districts the most severe effects of the earthquake were felt. The data for this investigation comprised thorough survey records of earthquake damage to buildings, pipes, and other structures in the streets, as well as early contour maps of the city. The results of this study showed plainly that the districts where the greatest damage occurred could have been predicted from knowledge of the original topography, and that the damage was due merely to the further settlement of loose soil, and to no other cause.

As these districts are well known, one of the objects in the construction of the system was to guard the pipe structures from serious damage, and for this reason special construction was adopted in the sections of the city where past experience had shown that the greatest precautions were advisable. While it is impossible to construct a system which is totally immune from damage by earthquake, the precautions adopted will greatly minimize the hazard to the lines.

**Cast Iron Pipe Chosen.**—After thorough investigation of different kinds of pipes, it was decided to use cast iron pipe throughout the system. This decision was un-

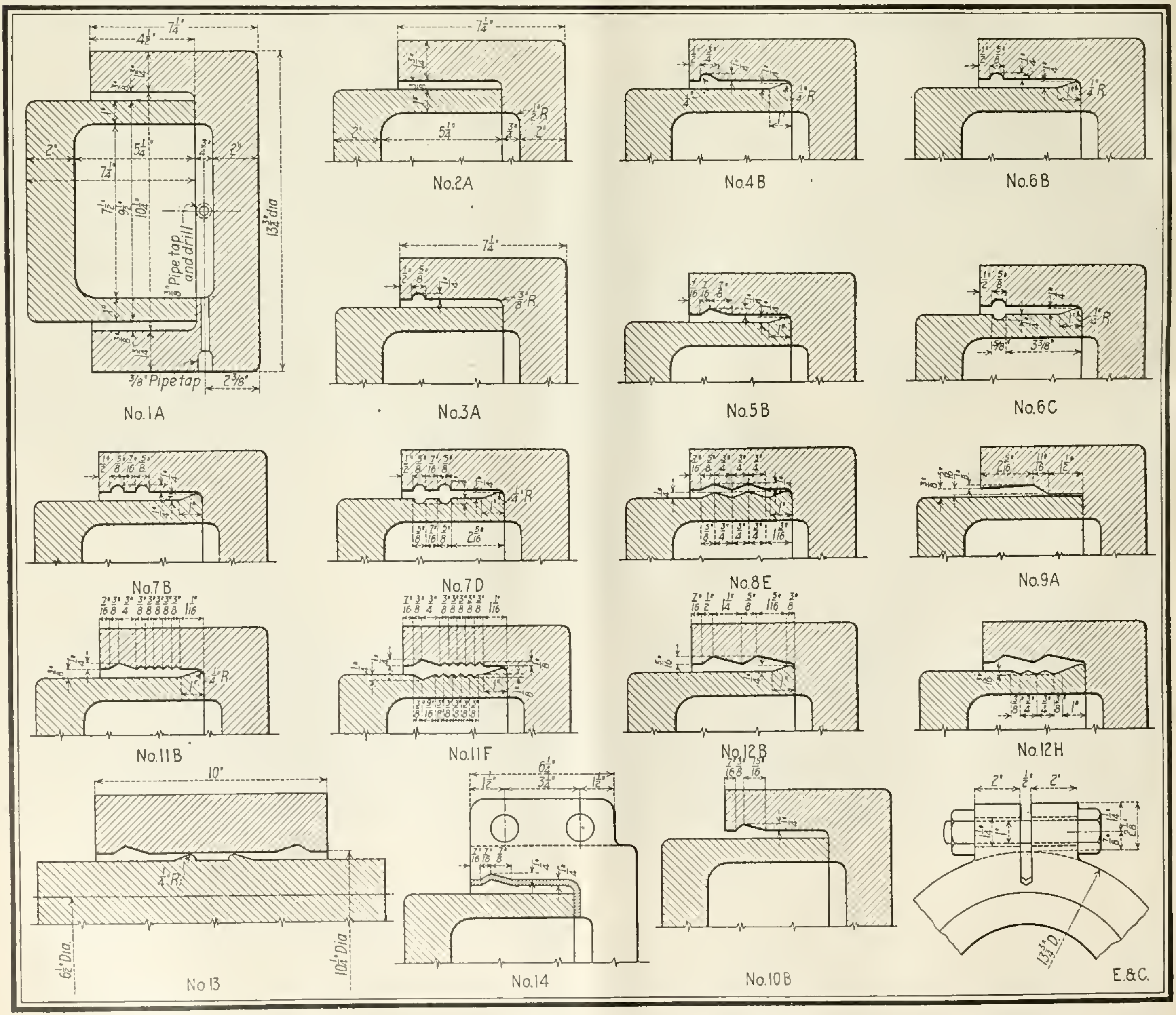


Fig. 1—Plan Showing Joints for Cast Iron Bell and Spigot Pipe Tested for High Pressure Fire System, San Francisco, Calif.

doubtedly wise, not only from the standpoint of the life of the pipe, but also because of the inevitable strains in any rigid structure such as a riveted or bolted pipe line due to the settlement of the soil. Under such conditions cast iron pipe offers many advantages, as the lead joint employed furnishes a remarkable flexibility without leakage. Cast iron pipe is also much better adapted to withstand compressive strains than steel pipe. The joint flexibility, and the endwise yielding under longitudinal strains offer most important advantages where serious settlement occurs.

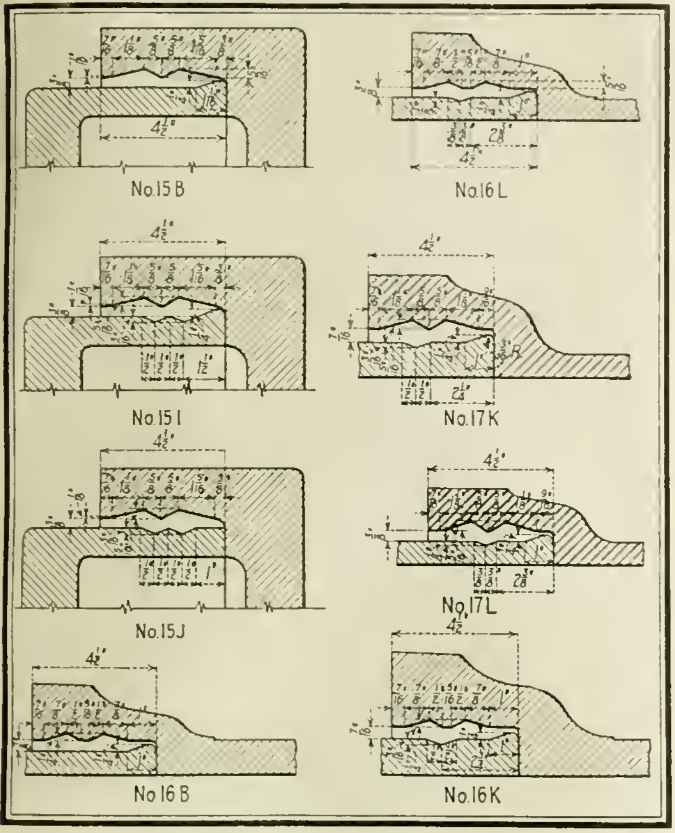
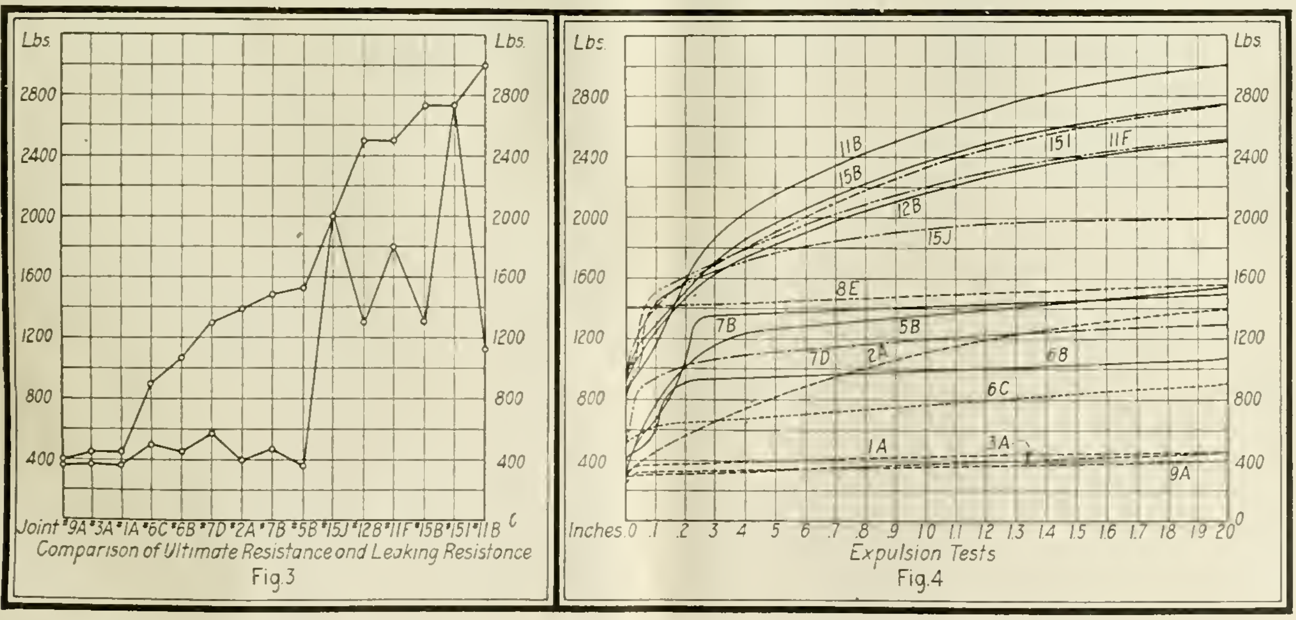


Fig. 2—Plan Showing Additional Joints for Cast Iron Bell and Spigot Pipe Tested for San Francisco High Pressure Fire System.

In the earthquake of 1906 there were places where the street lines were displaced several feet. Under these conditions any rigid pipe line would surely have failed. It is quite possible that in many places a suitable cast iron pipe line would have held without rupture and without material leakage, owing to the flexibility of the joints which would allow the pipe to be like a chain with rigid links.



FIGS. 3 AND 4—DIAGRAMS OF RESULTS OF SAN FRANCISCO PIPE JOINT TESTS.
Fig. 3—Comparison of Ultimate Resistance and Leaking Resistance. Fig. 4—Expulsion Tests.

**Designing Joints.**—In designing a joint for cast iron pipe to meet earthquake conditions; that is, ground settlement, one of the primary objects was to develop a type of construction which would meet the most severe mechanical conditions arising from earthquake effects, and yet would not involve unessential complications. This led to consideration of the problem from three standpoints: First, a joint with maximum possible strength; second, a joint which would allow a minimum leakage; third, a joint with maximum flexibility consistent with the first two considerations. The joint developed proved not only of exceptional strength, but also gave a minimum leakage, an important factor in economic operation. A very extensive investigation of the effects of different lead joints was undertaken, and the results obtained may be better appreciated by comparison with the New York High Pressure System where the leakage per foot of joint under corresponding pressure conditions was over 28 times as great as with the San Francisco System. To appreciate what this means it is well to bear in mind that not only is the foundation of much of the pipe in San Francisco of very poor material where considerable settlement will occur, but also a large part of the pipe is laid on steep grades. The leakage in New York under 30 lbs. pressure is approximately 1,250,000 gal. per day from slightly over 100 miles of pipe. At 10 ct. per 1,000 gal. this would be equivalent to $125 per day, or about $46,000 per year, which is interest at 10 per cent on a capital investment of $460,000.

**Comparison of Joint Efficiency in San Francisco and New York.**—The High Pressure System in San Francisco at present has about 73 miles of pipe, not counting about 3 miles of hydrant pipe. There are 18 miles of double spigot pipe included in the 73 miles above, and as this pipe has about twice the number of joints of bell and spigot pipe, this, from a leakage standpoint, is equivalent to 91 miles of bell and spigot pipe. The size of pipe in San Francisco varies from 10 to 20 in. It will average approximately the same as New York. The average pressure in San Francisco is about 140 lb. We may assume as an approximation that leakage varies with the square root of pressure. As a matter of fact it will vary as a higher power, since higher pressures will cause leaks where there will be none with low pressures, so this basis of comparison is unfavorable to the higher pressure. However, on this basis at 30 lb. the leakage in San Francisco should be $\sqrt{30/140} = .46$ times its present value. In March, 1916, the leakage in the San Francisco System was 78,495 gal. per day, which as above at 30 lb. would be about 36,000 gal. per day or 2.9 per cent of that in New York, and assuming 20 per cent increased length of joints for New York gives a leakage per joint of 3.5 per cent of New York.

This shows that in the design of systems the pipe joint efficiency is a very important consideration, and a high efficiency type of joint is justified at a greater initial expenditure. Another way of regarding this is that each joint in the New York system on the above basis will cost over 80 ct. more per year than in the San Francisco system.

The San Francisco High Pressure System was completed under the supervision of Mr. M. M. O'Shaughnessy, the present City Engineer. The system was commenced under the supervision of Mr. H. De H. Connick, Chief Assistant City Engineer, and Mr. T. W. Ransom, Consulting Mechanical Engineer, under Mr. Marsden Manson, City Engineer, the writer being engineer in charge of the design of the pipe system.

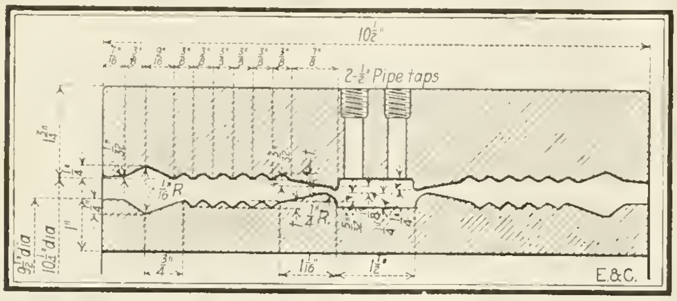


Fig. 5—Detail of Double Balanced Joint, San Francisco Pipe Joint Tests.

**Joints and Tests.**—Many different types of joints were tested for leakage, strength, deflection, etc., to determine their actual characteristics. The first series of tests consisted of expulsion tests to determine the joint strength, and the point at which leakage would commence. For this purpose a short plug and bell were used, the latter having a blank end. The outside diameter of the plug was 9½ in., corresponding approximately to an 8-in. pipe joint. The total joint length was 4½ in. A small hole admitted water to the interior. Record was kept of the total longitudinal motion of the plug caused by the expulsion pressure, and also of the pressure at which the joint started to leak. The back of the joint was caulked with yarn, and the joint was poured and caulked. In general three tests of each form of joint were made, and the results checked very closely. Pressures up to 1,500 lb. were supplied by an accumlator, and above this pressure by a hydraulic pump. While the pressures were kept on for some time for each reading, it should be borne in mind that lead being a slowly yielding material it is certain that the actual strength under continued pressure would be materially less than the values given, which are, however, comparative.

Figures 1 and 2 show the different types of joints tested. Joint 1A shows the plug and bell arrangement and also one type of joint. The number refers to the grooves in the bell, and the letter to the spigot arrangement. Fig. 3 shows the ultimate strength of joint and the pressure at which leakage starts from expulsion. The points are connected by lines, but there is no significance to the lines as curves. The upper line is the strength, and the lower line is the leakage point. It is to be noted that 15J and 15I are the only joints where no leakage occurs up to the failure of the joint. This joint 15 was the type which was adopted as standard; 15I was with spigot lip on the spigot end, while 15J was without this lip, as such lip is impossible with cut pipe. It is common practice in pipe foundries to put bands on cut pipes, as a certain number of pipes have the spigot ends cut where these ends are defective. These bands are flimsy affairs which frequently become loose in transit, and are entirely undependable. The cutting off of the lip on the spigot end shows a loss of strength of over 25 per cent, but this is generally unavoidable, as in practice it is usually necessary to use pipes cut to length in the field, as it would occasion much delay to have special cast lengths.

**Value of Strong Joints in Low Pressure Systems.**—It is desirable to have joints of the greatest maximum strength for city use, and this is most particularly true in San Francisco to guard against earthquake strains. In the laying of pipe lines in cities frequent bends are necessary to avoid existing structures. Also excavations adjacent to pipe lines may occur which render advisable great joint strength to allow for emergency conditions where the ground support is not fully available. It is true that joints in a straight line of pipe will not be subject to material stress, but even in these cases the stresses from expansion and contraction must be guarded against. These stresses, as well as the vibrations due to street traffic, occasion strains on the joints. Near dead ends and curves, additional stresses may come on the lines, though under these conditions the joints are usually reinforced by bolts. Hence the joint strength will add materially to the safety of the lines even in places where at first glance it may seem unnecessary.

**Test Diagrams.**—Figure 4 shows the relations between the pressure per square inch and the distance the plugs shown in Figs. 1 and 2 are expelled. It is seen that the joint will reach its maximum strength after it has moved out about 2 in. Up to that point the strength increases gradually. This is a most important point for meeting the conditions occasioned by earthquake, as any subsidence of the ground will tend to distribute itself along the line and to draw out the different joints instead of coming at one joint which would pull apart and break the line. Where bolts are used for reinforcing the joints, the design is such that the combined maximum strength of bolts and joint will occur. These bolts are generally of considerable length, and are made with the thread ends upset, and with the head ends upset with a gradually tapering cone before merging into the head, so as to make the shank the weakest part. The bolts are of wrought iron, and hence will resist corrosion to the best advantage. When a severe strain comes on the line, should they tend to rupture, they will stretch considerably before rupture, and thus develop the maximum strength of the lead joint, as well as of themselves, thus assisting in the very desirable joint features previously outlined.

One of the noteworthy characteristics of the curves of expulsion tests is that after the pipe starts to move it will at first move readily with slight pressure increases for distances from 1/16 in. to ⅛ in., and then require considerable increase of pressure to make further movement. This is due to the fact that the innermost part of the joint is of yarn, caulked to prevent the lead running through, and also the lead on the inside of the joint is not tight, as the caulking cannot reach so far in. The initial motion will compress this yarn, and solidify the lead. The lip on the spigot will tend to caulk this lead when the joint moves out, but the efficiency of this caulking effect is largely dependent upon the shape of the bell grooves. The best results obtainable were by the use of the joint of the type adopted, as is shown not only by theoretical considerations, but also by the practical results in San Francisco. The practical features of the bell grooves, which contribute mainly to these results, are the general shapes of the grooves, which afford for the outer part of the lead joint the most efficient design for practical caulking, and allow the inner part of the joint to be most effectively caulked by the spigot. To obtain this result the outer groove is made with a gradual taper on the outer side, and a steeper taper on the inner side, while the inner groove is made with a gradual taper on the inner side, and a steeper taper on the outer side. This results not only in better manual caulking of the outer joint, but also in the greater depth of caulking, as the taper will obviously allow the lead to be driven in to the best advantage. The position of the inner lead is such that the only way to caulk it is by the action of the spigot end, which will be called into effect if the joint tends to move. As the tapers of the inner groove are reversed with the outer groove, the best results of self-caulking due to motion of the pipe are obtained. In order to test the effects of caulking, special bells were made as shown in the lower right-hand part of Fig. 1, and marked No. 14. Tests were made in this manner on all types of bells and spigots.

After caulking, the bolts shown were removed, and the bells split open. The results showed the distance to which the caulking was effective, and indicated plainly that it was impossible to caulk over half the joint. Under these conditions the lead in the rear of the joint is ineffective until the joint starts to move, but after that it adds greatly to the joint strength, and also to the tighness in many cases.

Lead wool was tried in the joints, but the practical results were no better than with poured lead, although it was possible to compact the entire joint by caulking. This was of no practical avail, and the cost was far higher than with the poured joint. In order to withstand the contractions and expansions which must occur the joint should be of such a nature that this will cause no leakage. The use of plain spigot ends without grooves is therefore undesirable, as the working back and forth of a plain cylinder will cause a leak along the spigot. Hence the spigot end should be grooved. The nature of the groove is important, as should the sides be abrupt, it will cause shearing of the lead, a very undesirable result. Hence the grooves in the spigot should be with very gradual slope so that in motion of the pipe the lead in the grooves will flow under pressure, will not shear, and will always keep the joint tight. For mechanical reasons, the groove should be some distance in from the outer end of the joint in order not to weaken the pipe against transverse strains.

The maximum joint strength is that due to the shearing of the cylinder of lead comprising the joint. Hence with the same depth of lead the joint total strength is directly proportional to the diameter, and the strain thereon is proportional to the square of the diameter. Consequently, the ability of the joint to withstand rupture for a given pressure is inversely proportional to the diameter. As the same depth of joint was used in all pipes this holds true. The design of the joint, however, is not such as to allow rupture by shearing, as this would be undesirable, but the strength is somewhat less, so that the joint will fail by flowing of the lead, a much more desirable result, as is obvious.

In order to determine the leakage of different joints under conditions not connected with mechanical strains, such as would be due to the pressure tending to rupture the pipe longitudinally, a series of tests was made with a double balanced joint consisting of two cylinders forming respectively the bell and spigot ends of pipes, thus making the two joints of balanced nature, water being admitted between the joints, and the pressure tending to cause leakage, the only mechanical strain being the end pressure on the lead area. This is shown in Fig. 5, which shows a section of a joint of this nature. The first series of tests consisted in raising the pressure to different values and keeping it on for long periods. These tests were made on a few of the joints tested and while not of as much interest as some other results the curves are presented in Fig. 6.

Another set of tests was made with these balanced joints as follows: The center cylinder was mechanically displaced axially ½ in., and the leakage measured under 300 lb. pressure, the same pressure being used throughout these tests. The joints were then returned to the normal position, the leakage measured, and then the joint recaulked. This procedure was repeated in detail except that the second time the joint was displaced 1 in., and the third time 1½ in.

With joint 15I the following results were obtained, the leakages being in pounds of water per minute, leakages being different in all cases for the side pressed out, and the side pressed in. In all cases there was no leak whatever in the side pressed out. In the side pressed in the leakage at ½ in. was ½ lb. per hour; when returned to zero the leakage entirely ceased. When pressed out to 1 in. there was no leak, and when returned to normal there was still no leak. When pressed out to 1½ in. the leakage was 5 lb. per hour, and when returned to normal it was 2½ lb. per hour.

The following additional figures were obtained for leakage of different joints for the side pressed in when displaced 1½ in.:

| | |
|---|---|
| Joint 11B leakage, lbs. per hour | 80 |
| Joint 12B leakage, lbs. per hour | 120 |
| Joint 12H leakage, lbs. per hour | 24 |

Having developed a joint embodying the desirable features of strength and tightness under movement, the next investigation was on the subject of bursting strains in the bell member owing to the wedging action of the lead in the pulling asunder of the joint. To test the bursting of the bells, a series of tests was made on a 16-in. pipe joint. This was forced apart axially by a hydraulic press, the pressure showing, hence the power to cause failure of the lead joint. The hub of the bell member was next turned down, and the test repeated. This process was repeated until the hub finally broke in the expulsion of the spigot. As the turning removed the outer tough skin of cast iron, as a check the pattern was turned down and the tests repeated till the average point was reached where the bell would burst due to the expulsion pressure. This showed only a com-

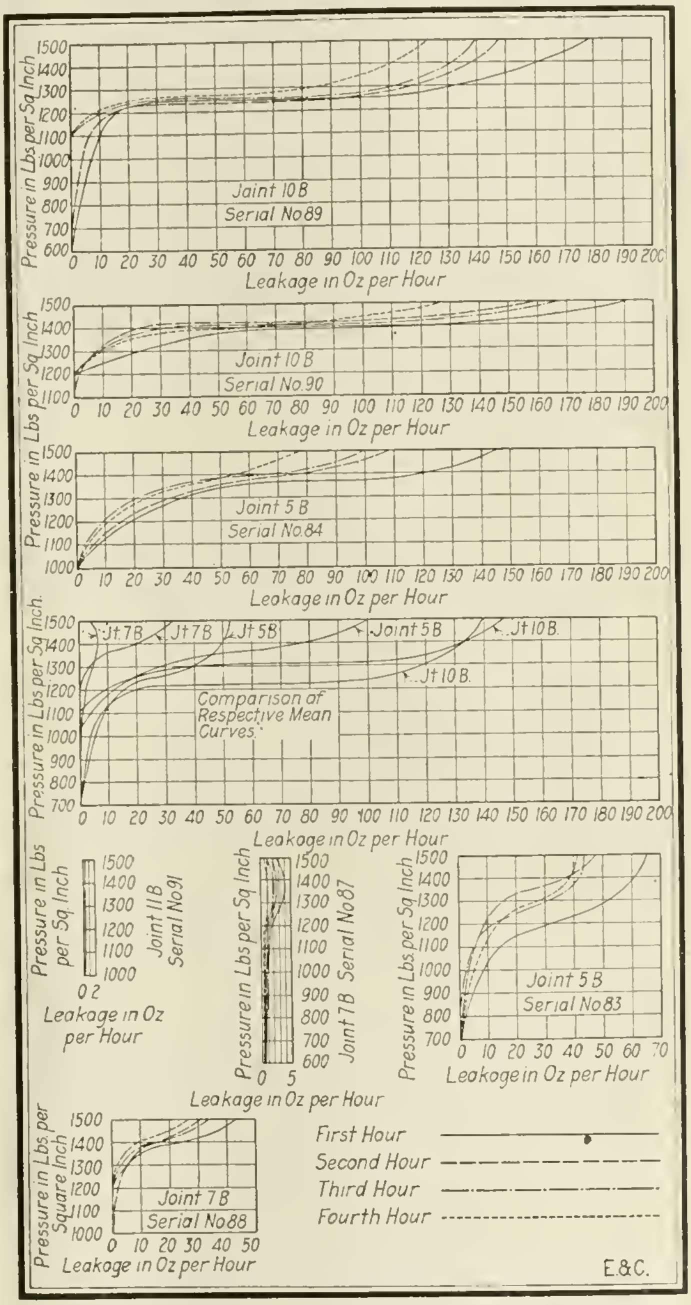


Fig. 6—Plat Showing Rate of Leakage from Double Balanced Joints Subject to Increasing Pressure.

paratively small safety factor in the case of a 16-in. pipe unless the hubs were greatly increased in thickness. This was regarded as undesirable, and hence the joints in the cast iron pipe were modified somewhat by making the lead space and grooves somewhat less. The extreme stresses induced by strains as above could come from strains suddenly applied, such as might occur from an earthquake. With the gradual stresses in practice, the yielding of the lead would prevent any such stresses coming on the cast iron. However, the endwise stresses to produce sufficient pressure to rupture suddenly the pipe are many times greater than the full dead-end pressures, and hence in considering the safety of the joints these matters have an important effect.

Joint 16K and 16L show the types of joint adopted for cast iron pipe, the former for larger and the latter for smaller pipe; 17K and 17L show corresponding joints for cast steel bells. Cut pipe had the spigot end grooved as in 15J.

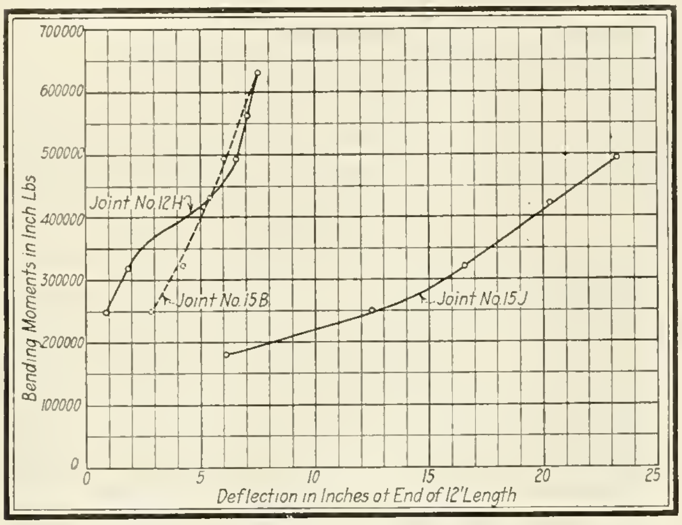


Fig. 7—Deflection in Inches at End of 12-ft. Length of 10-in. Bell and Spigot Pipe, San Francisco Pipe Joint Tests.

**Special Construction in Earthquake District.**—As has been previously mentioned, the districts subject to earthquake damage are well known, and for these districts special construction was used to take care as far as possible of the most severe strains. It was essential to provide bell of sufficient strength to withstand safely the full bursting strain caused by the sudden rupture of lead joints, or rather up to the point of such rupture which should be avoided if possible. For this reason all bells in this district, except the hydrant pipe, which is bolted, are made of cast steel. This gives an ample factor of safety. Also the pipe is double spigot pipe, and the cast steel bells are in the form of sleeves, thus making a double joint for each pipe. This adds an important safety factor to the system, as the possible yield of the joint is twice as great as with a bell and spigot arrangement. This yield is available not only for lateral distortion of the pipe, but also in allowing a considerable lengthening of the pipe, such as would be required were a great distortion to occur in the street. By allowing a possible increase of length of pipe of 4 in. per 12-ft. length, it is evident that very great distortions may be had without rupture.

The possible bending of the pipe was also investigated, the bending of course manifesting itself as yielding of the joints. Double spigot joint gives twice the possible bending of bell and spigot, which is believed to be ample to meet conditions. A series of tests was made to determine possible bending of the joints. Two lengths of 10-in. bell and spigot pipe were connected by a joint, and one pipe held rigidly, and the other pipe loaded at the end. Figure 7 shows the results of these tests, the deflections being at the end of a 12-ft. length. It is seen that the joint 15J, which differs from 15I fundamentally in having the lip on the spigot cut off, is far more flexible, but at the same time is not so strong.

For general use the stronger pipe is desirable, and will allow all desired flexibility.

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## METHOD OF TAPPING A 6-FT. MAIN INTO CONCRETE AND STEEL SHAFT UNDER PRESSURE.

Contributed by James Skelton, 70 Lawton Ave., Toronto, Canada.

Recently, when making extensions to the water works system of a neighboring city, it was found necessary to tap, at a point about 40 ft. below the surface, the vertical tunnel shaft through which was drawn the entire water supply of the city, and to connect there a 6-ft. main. As it was earnestly desired to do this without closing down the pumps, the job was one which called for considerable originality and engineering skill.

The tunnel shaft on which the operation was to be performed consisted of a brick and concrete pipe jacketed in steel, of 10 ft. inside diameter, and extending vertically downward in the rock a distance of about 90 ft. At the bottom it connected with a horizontal tunnel. It was proposed to construct a cofferdam in the shaft over the area affected, and to cut into the wall from the outside.

The cofferdam was, of course, built above ground and placed in position afterwards. In constructing it, a platform was first made, 80 ft. square, of 4x5-in. oak planks. On the upper side of this, flush with its four edges, were bolted 10-in. squared timbers. And on top of these—on the two end ones—were spiked two similar timbers, shaped on their upper sides so as to conform to the circular cross-section of the shaft; and the outside edges of the side timbers were beveled, so that they would fit snugly against the curved walls of the shaft. To make all water-tight, a thick rubber gasket was let in on the face of the timbers on all four fronts. Brackets of 2½x 10-in. channel iron reinforced the ends.

On the reverse side of the platform was bolted an A-brace of squared timbers, its feet flush with the sides and midway between the ends, the total height of the dam when the brace was in position being a little less than 10 ft. A horizontal bench-brace straddled the platform at right angles to the A-brace, its height about 20 in. less than the latter. Two eye bolts were let in on one end, and to these the hoisting cables were attached.

The cofferdam was now complete. It was heavily weighted with old iron—pieces of steel rails being strapped to the A-brace—so as to counteract its buoyancy, and then hoisted by derrick and let down into the mouth of the shaft.

A 6x8-ft. iron grating was suspended just below the level of the proposed opening in the side of the shaft, for the diver to stand on, and the dam was lowered to the required depth. It was carefully plumbed, and anchored by means of a large hardwood wedge driven between the apex of the A-brace and the tunnel wall. Two heavy jacks were then adjusted, their bases against the wall, their tops against the shoulders of the horizontal brace. A little at a time the jacks were tightened and the wedge driven home. The iron grating was removed. Four hours from the time the derrick swung it aloft the cofferdam was in place.

Outside the shaft an excavation had been made to the required depth on the side where the main was to enter.

A 6-ft. disc of metal was cut out of the shaft by means of an oxy-acetylene flame, and the concrete underneath removed. The dam was found to be correctly placed and absolutely water-tight. The pressure upon it was great, of course, and the jacks were further tightened to take up the slack caused by the removal of the wall. A steel flange, with stub connected, was now riveted on and a 6-ft. Glenfield & Kennedy (Kilmarnoch) valve installed. The valve was closed, and, about the pipe, all cased in cement.

It was found necessary to bore holes in the dam and admit the water before it could be removed.

Excepting for the few hours during which the actual work of placing and removing the dam was in progress, the pumps were raising their usual average of water per day. If they had had to be closed down at frequent intervals—as had been contemplated, in an alternative plan—it would have meant much inconvenience to the department which had the matter in charge and to the water consumers. The method which was adopted was an unqualified success.

## AUTOMATIC COAGULANT FEEDING DEVICE FOR MECHANICAL FILTERS.*

By M. F. Newman, Manager, Water Purifying Department, Wm. B. Scaife & Sons Co., Pittsburgh.

The apparatus as illustrated in Fig. 1 shows an automatic coagulant feeding device which is based upon using a saturated solution of coagulant made from aluminum sulphate or ferrous sulphate, depending upon the water supply. Briefly, this apparatus consists of a weir tank containing a fixed and an adjustable weir, a coagulant dissolving and saturating tank, the necessary pipe connections to introduce the coagulant solution, and means to keep the stream of coagulant solution from crystallizing.

In operation the water enters the weir tank, in which it is divided into two streams, the main flow of water passing out through the fixed weir and a small stream of water being passed through the circular adjustable weir. These weirs are of the same shape and are set on the same elevation, so that the depth of water flowing through them is the same; therefore, they are exactly in proportion. The water from the adjustable weir flows to the coagulant saturating tank. This tank is so constructed that the coagulant is partly submerged and the water coming from the adjustable weir flows over the submerged coagulant, then down through the submerged coagulant, through the wood fiber filter into the storage chamber in the bottom of the tank.

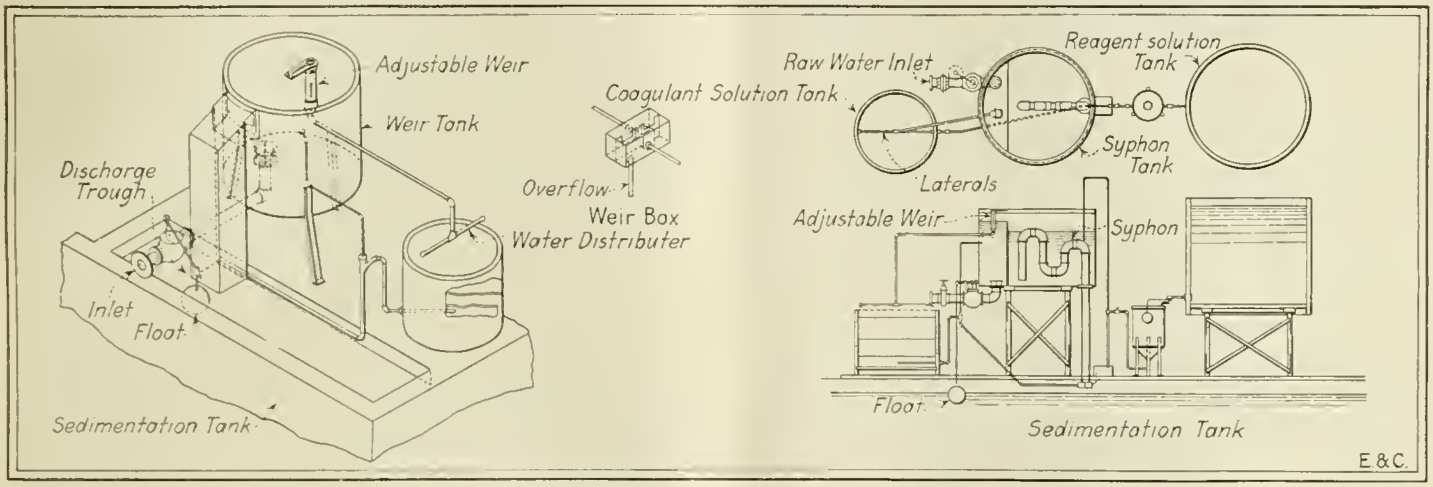

Fig. 1—Coagulant Feeding Device; Fig. 2—Device for Introducing Reagent.

The discharge pipe from the storage chamber is carried up to the height required for keeping a portion of the coagulant in submergence. The height of the discharge pipe fixes the level of the solution in the tank and the inflowing water from the adjustable weir displaces an equal volume of solution. The coagulant solution is delivered into the main stream of water flowing from the fixed weir. To prevent the strong solution from crystallizing and depositing in piping when exposed to the air, a small stream of water from the weir tank is constantly flowing into the discharge from the coagulant saturator.

It will be noted that there is an exact proportion between the water flowing from the weir tank into the sedimentation tank and that flowing into the coagulant saturator, varying with the height of water in the weir tank; also that when no water is supplied to the weir tank the flow of coagulant stops, and when the flow of water over the weirs again starts the proper proportion of coagulant is introduced.

The dry coagulant is introduced in lump form, and in order to charge the apparatus it is only necessary to introduce dry coagulant to maintain the proper level above the submerged coagulant in the saturator. The starting and stopping of the flow of coagulant is directly dependent upon the flow of water to the weir tank, and it does not require any opening or closing of valves to start or stop the flow of coagulant solution. To vary the quantity of coagulant solution, the adjustable weir is opened or closed. This weir consists of two slotted brass tubes, fitted one within the other, the inner tube stationary, while the outer one operates to increase or diminish the number of the slot openings. On top of the stationary tube is mounted a pointer which indicates on a dial on the outer tube the extent of the slot opening, which can be adjusted from a mere drip to a stream of any size required.

This apparatus has been in successful operation for several years, and in practice has successfully met all of the conditions for accurate and automatic introduction of coagulant, requiring but a minimum of attention.

In connection with the automatic coagulant feeding device there has been developed an automatic device for the introduction of a reagent, Fig. 2, to meet the conditions where the alkalinity of the water to be filtered is too low, or too variable within low limits to insure the proper decomposition of the coagulant. The apparatus, as illustrated, provides for the introduction of a reagent in exact proportion to the flow of water. This is accomplished by placing a partition in the weir tank before described and having the discharge of the fixed weir occur within the tank to fill the compartment in which the siphon is placed. When this compartment fills to the height which starts the flow through the siphon it continues until the compartment is empty. When this siphon begins to flow it starts an auxiliary siphon, which introduces the reagent solution during the period of its flow.

As soon as the compartment from which the main siphon operates is emptied, both siphons stop flowing until the siphon compartment again refills to the point where it starts the siphon to flow. The harmonious action of these siphons depends only upon the periodic rise of the water to the same height in the siphon compartment of the weir tank and a direct proportion is established between the flow of reagent solution and the flow of water to the sedimentation tank through the siphon. The reagent introducing siphon is connected to a constant level tank supplied from the reagent solution storage tank. The siphon draws from the constant head tank under a uniform condition, so that the volume of solution for any given period of siphon discharge is constant.

This siphon reagent feeding device is adaptable for one or more solutions, and with it a solution of hypochlorite of lime can be introduced into the effluent from the filter, and the flow automatically controlled by means of the flow of water into the filter system, so that when no water is flowing to the filter system no solution is introduced, and when the flow starts the introduction of solution starts without the necessity of opening or closing valves.

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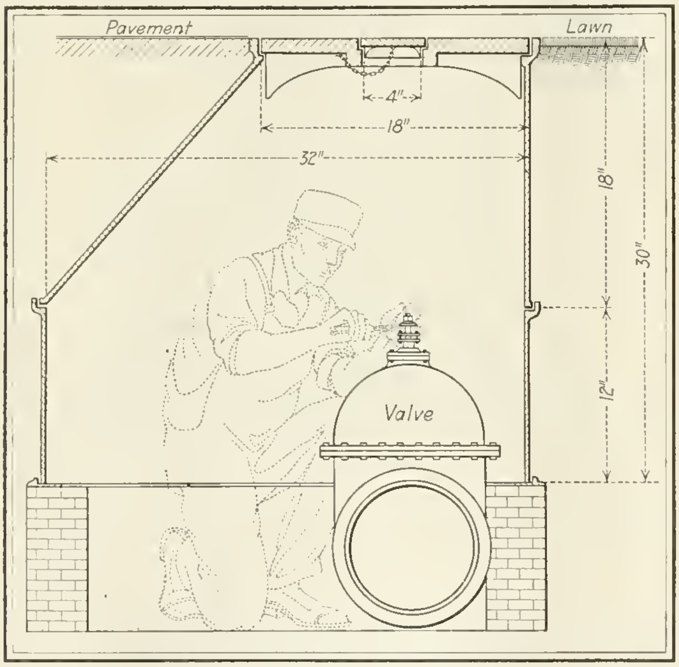
*Proceedings, Engineers' Society of Western Pennsylvania, January, 1916.

The primary principle underlying these two devices, that is, the control of the feed as a function of the water flowing to the system without depending upon the human element for starting or stopping, is, in the writer's opinion, a decided advantage, and one that is extremely desirable, in view of the variations that occur in the flow of water to a filter system, and the difficulty in securing first-class supervision of the operation of filtration systems, to compensate for variations occurring in practice in the flow of water or periodic pumping.

## A CONVENIENT HOUSING FOR GATE VALVES.

The sketch herewith shows a cast iron housing for gate valves or for any other underground appliance that needs to be got at ocasionally for inspection or repairs. Very little explanation is required of the main structural features except to note the eccentric shape of the housing which permits ample working room without excessive dimensions. The cover is the particular feature. As shown it consists of the main cover having within it a small lid. A man to get inside the housing removes the main cover, but for operating the valve and for such other purposes as do not require entrance into the housing the man works through the small lid. It will be noted that the lid opening is too small to permit entrance of a horse's hoof or a man's foot and that it is secured against loss by chains molded into the castings. This valve box was one of the exhibits of the H. W. Clark Co., Mattoon, Ill., at the recent convention of the American Water Works Association in New York City.



Clark Housing for Gate Valves.

## PROPOSED STANDARD FREEZING AND THAWING TESTS FOR DRAIN TILE.

Revised standard specifications for drain tile proposed by the committee of the American Society for Testing Materials include new specifications for standard absorption tests and freezing and thawing tests, and corresponding test requirements. In preparing these new specifications, the committee was fortunate in securing the co-operation of the testing laboratories of the University of Wisconsin, of the Lewis Institute, Chicago, Ill., of the Iowa State College, and of Prof. Edward Orton, Jr., of Columbus, Ohio, which laboratories placed at the disposal of the committee the results of extensive absorption and freezing and thawing tests of actual drain tile. The committee wishes to make special asknowledgment of the valuable services of Prof. M. O. Withey, of the University of Wisconsin. The committee believes that no such large mass of data of absorption and freezing and thawing tests of drain tile have ever before been available for use. Great care has been taken in studying and digesting the data on which the revised specifications are based. The main requirements of the test are as follows: When the specimens (either from the absorption test or from a specially prepared series) have been weighed after saturation with water, they shall be returned to the water, and kept immersed till the freezing test is begun. For freezing, they shall be placed with their concave faces upward in water-tight metal trays, suitably mounted in a rigid metal crate, Fig. 1, and immersed in ice water until the specimens have attained substantially the temperature of the water, after which the water shall be drawn down to a depth of ½ in. in each tray. The crate shall then be lifted as a whole, without disturbing the specimens, and placed in the freezing apparatus.

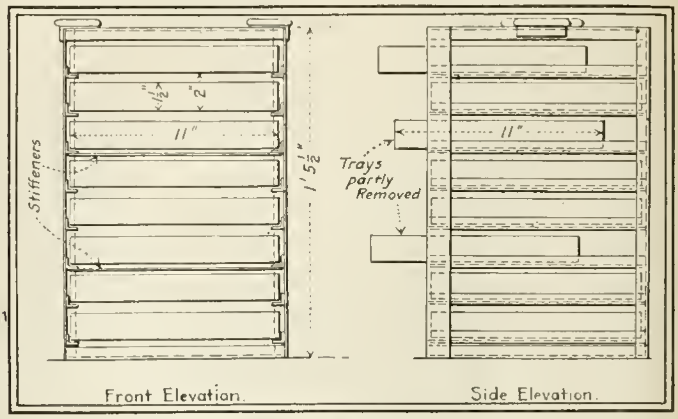


Fig. 1—Rack for Freezing Tests of Drain Tile.

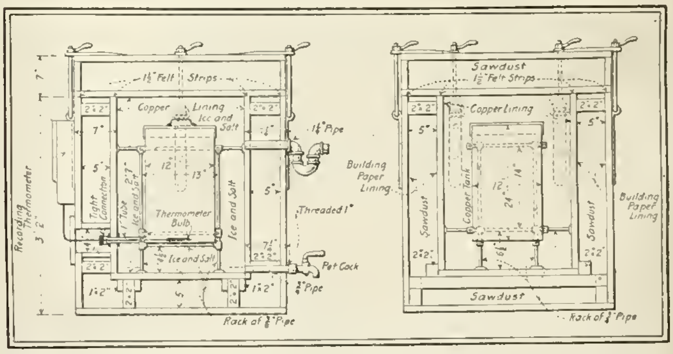


Fig. 2—Freezing Apparatus for Drain Tile Tests.

Freezing shall be performed in a quiet atmosphere, free from perceptible natural or artificial currents. If artificial freezing apparatus, Fig 2, is employed, the apparatus shall have sufficient heat-absorbent capacity to enable the temperature of the freezing chamber to be brought to —10° C. (+ 14° F.) or below, within 30 minutes after the introduction of the specimens. The temperature in the freezing apparatus shall not fall lower than —20 C. (—4° F.). The freezing shall be continued until the water in the trays is frozen solid. Exposure to freezing conditions in excess of this requirement shall be considered as without significance.

At the conclusion of freezing under the specified conditions, the crate of specimens shall be withdrawn and at once immersed in water at a temperature of 85 to 100° C. (185 to 212° F.) in a special receptacle of proper size. Heating shall be continued so that the water will regain the required temperature as soon as practicable after the specimens are immersed. A temperature of 85 to 100° C.

(185 to 212° F.) shall then be maintained for not less than 15 minutes. At the conclusion of the thawing treatment, the crate of specimens shall be cooled down rapidly in water to 10 to 15° C. (50 to 59°F.) and then inspected. The condition of each sample after each thawing shall be noted in the records.

Failure under the freezing and thawing treatment shall be considered to be reached when:

(a) The specimens show superficial disintegration or spalling with loss of weight of more than 5 per cent of the initial dry weight; or,

(b) The specimens are badly cracked in other than lamination planes; or,

(c) The specimens show evident serious loss of structural strength.

## NOTES ON METHODS AND COST OF MAKING SURVEYS FOR SEWERS.

Contributed by Albert M. Wolf, Melrose Park, Ill.

The appended notes on the making of surveys preparatory to the design of sewer systems for towns and average sized cities, were jotted down by the writer several years ago, as the result of experience gained in making such surveys in a considerable number of towns and cities in Wisconsin and Michigan under the direction of W. G. Kirchoffer, sanitary and hydraulic engineer, Madison, Wis. The writer feels that they may be of some value to the young engineer engaged in sanitary engineering work and they are therefore briefly set forth in the following.

Preliminary surveys of a more or less approximate nature for the purpose of gaining some idea of the approximate cost of a sewer system can best be made as follows:

(1) Run an accurate line of bench-mark levels around the district to be surveyed, to serve as checking points in the latter work.

(2) Take levels at all street intersections, and at middle of blocks or wherever the general grade of streets changes in order to get the trend of drainage.

(3) Obtain a city plat and plot thereon the elevations of the various points obtained in the rapid survey just mentioned. Then map out the possible and most probable routes for main and branch sewers. If all streets are not to be sewered, such a plat is very handy for determining the best routes, thereby saving the expense of complete surveys.

The cost of such preliminary surveys varies from $5 to $10 per mile of sewer depending on the character of the topography, the rougher the territory, the greater the cost.

Complete surveys for the making of detail plans can be made in the following manner and the best results insured.

(1) Take levels along center of street (if sewers are located in center of street) every 50 ft. or 100 ft. or more often as the topography demands, measuring all distances with a steel tape. For convenience in plotting profiles the 0+0 station for all east and west streets can be taken at the west end, and at the south end of all north and south streets. Take elevations of water tables (on frame house this indicates the ceiling of basement) of buildings on each side of street at beginning, middle and end of every block or such as may be considered representative or unusual. Then by obtaining the average height of basements (7 ft. for residences and 9 to 10 ft. in business blocks) and referring them back to water table elevations, the elevations of basement floors can be plotted on the profiles. Take the pluses of all water tables of which elevations are taken, all street and alley lines passed, these to be plotted on the profiles and after balancing and comparing with the distances given on plat, they aid materially in preparing the sewer map which is based on city maps and subdivision plats.

(2) While engaged in field work a small scale map such as can be pasted in the field book will be found very handy for indicating progress of the survey and entering notes regarding special points.

(3) If the outlet sewer is not located on the street the territory which it is likely to transverse should be surveyed more carefully either by level readings located by cross-sectioning or by stadia, so that the shortest and best route can be readily laid out in the office.

(4) If a disposal plant is to be built, stadia topography should be taken so that a contour map of 1 ft. interval can be plotted and estimates of cut and fill, fall through plant, etc., can be readily made.

(5) The cost of surveys such as just described together with complete map compiled from city records, profiles and estimates will be about $60 per mile where the topography is not too rugged.

General (not detail) plans including a map (compiled from city records) showing size of sewers, grade and elevations of sewer and ground at manholes, mid-block and all breaks in grade, without profiles, can be made for about $20 per mile and including cost of survey.

Where territory which has not been plotted must be surveyed in order to properly design sewers for future needs, a topographic survey of the area should be made. The cost of such surveys including maps will, for rolling and flat country (2 ft. contour interval), be from 35 ct. to 50 ct. per acre, and for rugged country (5 ft. contour interval), 75 ct. to $1 per acre.

## FORMATION OF ICE IN WATER MAINS.*

The formation of ice in water mains is dependent upon the temperature of the water in the main and the velocity of current, the pressure being of negligible effect. It is probable that the water as drawn from a reservoir or stream is seldom below 33° F., as the formation of ice and the density of the water generally prevents the cooling of the water below this temperature. If the water in passing through the main is not reduced in temperature to below 32° F. there will be no danger of freezing. If it is reduced below 32° F. ice will begin to form, the ice forming a coating on the inside of the pipe, due to the high conductivity of the iron. As the ice film thickens, the transmission of the heat of the water to the surrounding earth and thence to the air is greatly retarded, the conductivity of the ice being such a small fraction of the conductivity of the iron. If the velocity in the main is reduced through a lowering of the rate of draft, the water in the main is more readily cooled, and the rate of ice formation correspondingly increases. This ice formation may be properly classified as surface ice. It is probable that in a main where the velocity is high, the water is cooled slightly below the freezing point and a form of frazil ice created. Such ice might eventually clog the main, stopping the flow, and the whole mass of water in the main quickly change to solid ice. In the report of the committee of the New England Water Works Association on the depth at which mains should be laid to prevent freezing, submitted in 1909, reference is made to slush ice forming in a main laid in a salt marsh at New Brunswick, N. J. The velocity in this main was high and frazil ice probably formed. A stoppage in flow may also occur after a thaw, due to the loosening of the film of ice which has forced during the cold spell, and which may break up and flow through the water until it reaches a point in the main where the ice may not have broken loose and where the floating ice will become packed in such a manner as to completely stop the flow. While this might account for the stoppage of flow in mains, especially in house services, after a thaw, which is an experience not uncommon to water works superintendents, there is a record of an actual reduction in temperature of soil below 32° F. following a thaw, and such reduction would be ample reason for the freezing up of water mains.

Good progress has been made with the engineering work for the new $12,000,000 water supply project of the city of Providence, R. I., and it is expected that some of the construction will be placed under contract this fall.

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*Extract from a paper by Wm. W. Brush before the Four States Section of the American Water Works Association.

## PERSONALS.

Faulkner G. Lynch has been elected city engineer of Erie, Pa.

Roy Welsh has been appointed city engineer of Centralia, Wash.

Joseph Barry has been appointed superintendent of street cleaning for the city of Syracuse, N. Y.

Charles E. Fanning, a paving contractor of Omaha, Nebr., has been nominated by President Wilson as postmaster of that city.

Chas. A. Lindberry, city engineer of Ferndale, has announced his candidacy for county engineer of Whatcom County, Washington, for the fall election.

The new state highway commissioner was a member of the state board of agriculture, to which he was appointed by Governor Brumbaugh on June 10, 1915.

Fletcher A. Gould has been appointed city engineer of Owosso, Mich. Mr. Gould was formerly professor of civil engineering at Millikin University, Decatur, Ill.

Samuel Hill, of Seattle, Wash., has gone to Vladivostok, Russia, at the request of the Russian government, to take charge of the traffic department of the Trans-Siberian railway.

William W. Rumsey has been appointed engineer in charge of the division of construction and maintenance in the recently created bureau of illuminating service of the department of public works of Milwaukee, Wis.

S. S. Carroll, for several years in charge of hydrographic work for the state engineer at Albuquerque, N. M., has resigned to become resident engineer for the Las Vegas grant board on the irrigation project to be built near that city.

A. N. Krieger, a graduate of the Baltimore Polytechnic Institute of Baltimore, Md., and a member of the 1916 class of the Carnegie Institute of Technology, has been awarded first prize by the Engineers' Society of Western Pennsylvania, for the most accurate solution of an original problem in structural engineering.

J. McGregor, superintending engineer of the Ocean Terminals at Halifax, now under construction, has obtained leave of absence from the Canadian department of railways and will join the British army. He will be chief engineer of the railroad construction battalion commanded by Col. J. W. Stewart and will have the rank of major.

Frank B. Black, of Meyersdale, Somerset County, was appointed state highway commissioner of Pennsylvania by Governor Brumbaugh on July 1, filling the vacancy created by the death of Robert J. Cunningham, which occurred at his home in Sewickley, on April 26. Commissioner Black took the oath of office on Wednesday, July 5, and immediately thereafter assumed control of the department. His first official act was to issue a statement in which he said that he would carry out, as far as possible, the policy instituted by his predecessor and that he would give the state highway department an efficient and business administration.

Frank B. Black, State Highway Commissioner.

Frank B. Black was born at Somerfield, Somerset County, April 17, 1864, and has lived in the county of his birth all of his life. He comes from a sturdy ancestry and a pioneer family of the Youghiogheny River section of Somerset County. His father, the late George J. Black, was a man of ability, industry and enterprise, traits which are characteristic of the family. The elder Black was a pottery manufacturer, merchant and farmer and was elected to the office of Associate Judge and County Treasurer, which positions he filled with signal ability.

The family removed from Somerfield to Meyersdale in 1873 and the newly-appointed State Highway Commissioner grew up in the latter town and received his education in the public schools there. At the age of eighteen he was much further advanced in business experience than most men of thirty and at that early age he purchased his father's interest in the coal mining industry and began opening and operating coal mines in various parts of the country. He organized and developed many coal properties, selling them when he had them well established. For some years, with several associates, he mined and sold coal through their own selling agency in New York, under the firm name of Black, Field and Emmons Company. In 1907 he organized the Atlantic Coal Company which has mines at Boswell and Blackfield This company is a large producer of coal and employs between 500 and 600 men. It has two of the best equipped and best managed coal mining plants in Somerset County, both of which have been under the personal direction of Commissioner Black.

James A. Farrell, commissioner of public works of Duluth, Minn., has appointed the following engineers as an advisory board for his department: W. A Clark, chief engineer of Duluth and Iron Range Railroad; Clarence Coleman, of the United States engineering corps; A. M. Gow, mechanical engineer; W. H. Hoyt, assistant chief engineer, Duluth, Missabe & Northern Railroad; John U. Sebenius, general mining engineer of Oliver Iron Mining Co.; T. F. MacGilvray, civil engineer; W. B. Patton, civil engineer; John N. Pickels, chief engineer Canadian Northern Railroad; S. S. Rumsey, chief engineer of Oliver Iron Mining Co., and Francis W. Sullivan, civil engineer and attorney. The members of the board will serve without pay, and their advice will be sought on all important matters and no steps will be taken by the public works department until the board has had ample time to study and pass on it.

## OBITUARY.

W. R. Tinsley, for 35 years district superintendent of maintenance of ways of the Atlanta and West Point and the Georgia Railroad, died June 30, at Atlanta, Ga.

Joseph Ramsey, Jr., president of the Lorain, Ashland & Southern R. R., died suddenly of apoplexy on July 7 at his home, 55 Lenox Ave., East Orange, N. J. Mr. Ramsey was born in 1850 at Pittsburgh, Pa., and was educated at the Western University of Pennsylvania. From 1869 to 1870 he was in the engineering corps of the Pittsburgh, Cincinnati, Chicago and St. Louis Ry., and in July and August of the latter year he was engineer of construction of the Dresden cut-off. From September, 1870, to May 21, 1871, he was assistant engineer of the Cincinnati & Muskingum Valley R. R., and from May to October, 1871, chief engineer on location of the Bells Gap R. R. From October, 1871, to April, 1872, he was assistant engineer of the Lewistown division of the Pennsylvania R. R. From April, 1872, to 1878 he was engineer. From the latter year to 1879, chief engineer and superintendent of the Bells Gap R. R. From January to November, 1879, he was chief engineer and superintendent of the New Castle & Lake Erie R. R., and from the latter date to April 1, 1882, he was chief engineer and superintendent of the Pittsburgh Southern R. R. In March, 1882, he became chief engineer and general manager of the Pittsburgh, Chartiers & Youghiogheny R. R., continuing in this position until August, 1883. In this year he also became chief engineer and general manager of two other roads and of the Chartiers Block Co. From August, 1883, to 1886, he was engineer, and from 1886 to 1890, chief engineer of the Cincinnati, Hamilton & Dayton Ry. From Jan. 1, 1890, to June 1891, he was assistant to the president of the Cleveland, Cincinnati, Chicago & St. Louis Ry., and from March, 1890, to March, 1895, president of the Peoria & Pekin Union Ry. He was general manager of the Terminal Railroad Association of St. Louis from April 1, 1893, to Dec. 1, 1895, and from the latter date to June 20, 1901, vice president and general manager of the Wabash R. R. He became president of this road in June 20, 1901, and continued in this position until April 19, 1905. He also had been president of the Wheeling & Lake Erie R. R., the Ann Arbor R. R., and the Western Maryland R. R.

## NEW CATALOGS.

**Pipe.**—Paper, 5x8 in. National Tube Co., Pittsburgh, Pa.

This is the new edition (revised and enlarged) of "National" Matheson joint pipe booklet. It contains many new photographs of installations of this pipe. Several of these installations, judging from the views, were made under very difficult conditions. The booklet contains much information of interest to engineers and contractors.

**Cleaning Water Mains.**—Paper, 6x9 in.; 24 pp. The National Water Main Cleaning Co., 50 Church St., New York City.

Discusses the causes and effects of dirty mains and describes the method employed by this company in cleaning the pipes. A table is given showing the results obtained in 45 cities by cleaning the water mains. Data also are given on the cost of pipe cleaning.

**Meter Boxes.**—Paper, 6x9 in.; 52 pp. H. W. Clark Co., Mattoon, Ill.

This is catalog N. It contains a description of the Clark Meter Boxes and also of the various water works appliances manufactured by this company. Numerous reproductions of photographs showing typical installations are given, as well as several drawings giving details of the meter boxes.

**Pumps.**—Paper, 9x12 in.; 12 pp. D'Olier Centrifugal Pump & Machine Co.

This is a Bulletin, Series G, No. 1. It describes particularly the Wood Screw type pumps for irrigation and drainage service. Illustrations are given showing installations at the Terrebonne Drainage District. The bulletin also contains descriptions of special types of D'Olier centrifugal pumps, of a reinforced concrete case pump, and D'Olier centrifugal volute and multi stage pumps.

## INDUSTRIAL NOTES.

On July 1st the Seattle, Wash., office of the Lidgerwood Mfg. Co. was removed from 807-809 Western Ave. to new quarters at 63-65 Columbia St.

Mr. A. R. Murphy, Jun. Am. Soc., C. E., of Knoxville, Tenn., has become associated with the engineering staff of Wallace & Tiernan Co., manufacturers of Chlorine Control Apparatus, New York City. Mr. Murphy is a graduate of the University of Tennessee and has had several years' general waterworks experience.

E. R. Marker, District Manager of the T. L. Smith Co., has moved to new quarters at 509 Wells St., Milwaukee, Wis., where he takes charge of the business of the company as Wisconsin Representative. Mr. Marker will carry a stock of mixers on the floor and will also stock a complete line of contractors' supplies.

John Bennett Bissell, formerly President of John Bennett Bissell, Inc., exporters, has resigned to join the organization of the Blaw Steel Construction Co., Pittsburgh, Pa. Mr. Bissell will be Manager of the Export Department, and the Eastern Structural Sales Department, and will be located at the company offices, 165 Broadway, New York.

The Ransome Concrete Machinery Co., with executive offices at 115 Broadway, New York City, and an enlarged factory at Dunellen, N. J., has just established another office at St. Louis, Mo., number 12 to 18 South 12th St. The agent there is Mr. E. Gwynn Robinson. He will have a show room where the latest type of all kinds of mixers, from the smallest bantam to the road paver, will be on exhibition.

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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## ANNOUNCEMENT OF THE EXCAVATION AND RAILWAY MONTHLY ISSUE OF "ENGINEERING AND CONTRACTING."

Beginning ten years ago this journal made a practice of publishing a section every week devoted to earth and rock excavation articles. Three years later the "Dirt Mover" was purchased and made part of "Engineering and Contracting." The editor is author of two books on excavation. With changed titles and greatly enlarged, each volume containing about 400,000 words, these two books are now in the printer's hands. The new titles are "Handbook of Rock Excavation" and "Handbook of Earth Excavation."

We mention these facts to indicate the importance attributed by the editors of "Engineering and Contracting" to the "dirt-moving field." But as a further earnest of our belief in its importance we announce the intention of devoting the third issue of every month to articles on excavation and railways. This issue, to be called the Excavation and Railway Monthly, will be sold for $1 a year. As stated on the front cover, any two or more monthly issues will be sold in combination for 75 ct. each per annum, and every issue (52 yearly) can be secured for $3.

We believe that many contractors, superintendents and engineers who specialize in excavation will find the articles in our Excavation and Railway Monthly all that they need to keep abreast of "changes in the art." Many contractors of course will require in addition contract news service that we give in our construction news section every week. This combination of a periodical service on excavation articles and a weekly service on contract news is given by no other periodical in America. We believe it to be the most rational solution of the problem of furnishing all classes of readers with the sort of information desired and at a subscription price that is exceedingly low for the quality of service rendered.

The articles relating to railway work will be mostly of the sort that interest the railway contractor and the engineer in charge of railway construction. While railway construction has been scarce during the past few years, the great prosperity of American railways during the last eighteen months is certain to be followed soon by a large amount of railway betterments, additions and extensions.

The tide of public regulation of railway rates has turned strongly in favor of the railways. Railway valuations are disclosing the fact that few railways are overcapitalized, and therefore not many are earning exorbitant profits. The editor appraised $225,000,000 of railway property for a Western state several years ago, and then learned how greatly to the advantage of all railways would be similar public official valuation of railway property. Each successive appraisal since then has served to confirm his opinion that the political salvation of the railways lies largely in such appraisals.

Land reclamation, by drainage and by irrigation, will show greater progress in the next ten years than in the past, for the prices of agricultural lands have mounted at a startling rate. The high prices of foods of all kinds are indicative of the relative scarcity of improved lands. Mouths to be fed have increased more rapidly than farmed acreage. To engineers and contractors the significance of these facts is this: Land reclamation projects will secure a better financial welcome hereafter than heretofore. Capitalists and the government have learned better how to put farmers on newly reclaimed land, and the costly mistakes of waiting for farmers to flock to the new lands will seldom be made again. Proper publicity, coupled with loans to farmers, will solve the problem of putting men on the land.

Road grading has already become an important class of excavation work, but roadwork is still in its swaddling bands. Pleasure cars and motor trucks are multiplying with incredible rapidity. Roadwork lags behind that multiplication, but each year sees a substantial increase in road construction. Now that Uncle Sam is about to spend $85,000,000 on roads, to which the states that are aided will add another $75,000,000—a total of $160,000,000 on roadwork in the next five years—there is assurance that roadbuilding will not long lag behind the building of roadmobiles.

To the "dirt movers" it may be said that all signs and portents for a prosperous future are better now than at any time during the past decade.

## A MEMORIAL TO DAVID DU BOSE GAILLARD.

The members of the Third United States Volunteer Engineers have performed a fitting act in publishing a memorial volume to Colonel David Du Bose Gaillard who was their regimental commander in the war with Spain. For his work at Panama Colonel Gaillard received ungrudging praise by the public, for in Culebra Cut the public had a work of engineering the magnitude of which the public could understand. To engineers, however, this work only confirmed the proof which previous work had given of the exceptional engineering knowledge and skill of its immediate director. This memorial volume is not a review of Colonel Gaillard's engineering work at Panama and elsewhere; it is an assemblage of appreciations of the man and the engineer from the pens of those who knew him and his accomplishments. To few men in a generation comes so unanimous recognition of service rendered; it should make every engineer gratefully proud that it was to an engineer that it came.

## IMPROVED BLASTING PRACTICE IN COAL MINING.

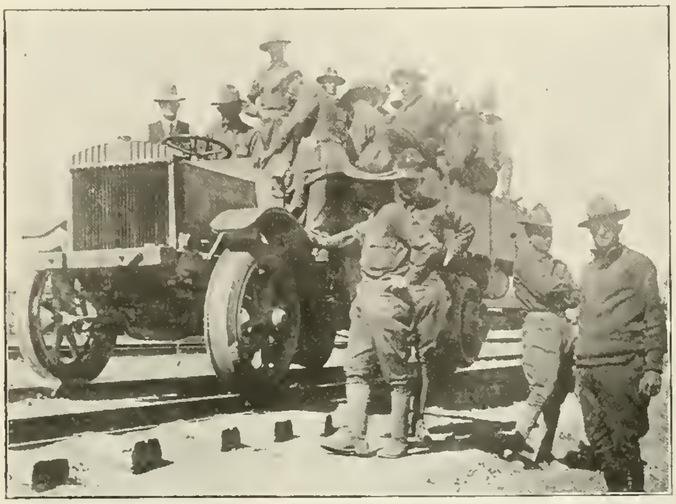
The increasing use of permissible explosives in coal mining in the United States has been accompanied by the material reduction of 72 per cent in blasting accidents since 1903. These figures are according to the records of the Bureau of Mines. Also these records show that at least one-fourth of all blasting accidents are premature blasts caused by miners using short fuses and defective squibs. There is obviously an opportunity for improvement in coal mining of methods of firing blasts. It can be met by substituting electric firing for the antiquated method of fuse and caps. There would seem to be scant reason why this change should not come about. Most coal mines now employ electric firing and those which do not could. The cost of installation is small. A blasting machine suitable for coal mines costs about $10 and will last for years if properly cared for. Electric blasting caps cost little if any more than fuse and blasting caps and the cost of leading wire is small. Contractors for rock excavation very generally employ electric firing, but there are a few who do not, and to these few the reasons for its adoption in coal mining apply as forcibly as they do to coal miners.

## WHY NOT AUTOMOBILIZE OUR RAILWAYS?

Twenty years ago when the trolley car began to cut into the passenger receipts of railways, the loss of business was taken as philosophically as if it were an "act of God." Had steam railway managers been quick to seize the new invention of electric transportation, we should today have few independent interurban trolley lines and more economic transportation.

Now we are witnessing a similar failure on the part of all railway managers—electric as well as steam—to seize the newest instrument of transportation. Motor trucks are already "stealing" much of the short-haul freight traffic. Why not automobilize the railways?

Because Carranza would not permit American troops to use Mexican railway equipment, some genius in our army temporarily transformed motor trucks into railway rolling stock by fastening detachable steel flanges to the motor-truck wheels. Thus the trucks were driven over the railways, where there were railways available, and over dirt roads when no railways were available. The change from a rail vehicle to a dirt road vehicle is quickly made, and thus the problem of automobiling one railway system was speedily effected in part.



Motor Truck Equipped With Removable Flanges to Run on Railway Track.

Innumerable rail lines carry only a few trains daily, and the train loads are not great at best. There is every reason to believe that much of the freight traffic over such lines could be more cheaply handled by motor trucks adapted to run on rails as well as on roads.

The one great economic principle that American railway managers have always treated with scant consideration is this: Every equation of unit costs should contain every element in the total cost, and should be solved for a minimum unit cost. In transportation the total cost is not the rail cost alone, but includes delivery to the rail terminal at one end and conveyance to the destination at the other end, as well as the handling and fixed charges at all terminals.

Railway managers have always had their eyes centered on what they regarded as being their part of the transportation cost—the rail part. They have very largely ignored the part of the total cost that is now much greater in the aggregate than the cost of rail haulage. Does not a broader vision dictate a complete change in railway policy? May not the pressing and perplexing problems of furnishing adequate terminal facilities in large cities be solved by automobilizing the terminals?

Why will it not be economic to transfer nearly all freight from cars to motor trucks outside the limits of large cities, run the trucks into the cities on rails, remove their temporary wheel flanges and thus enable them to run over paved streets to their destinations?

Railway managers, wake up! Come out of your narrow path, and beyond its extremities, into all the highways of transportation. View transportation in its entirety as your real field of action, and you will add more to human wealth than you have already added—which is a vast deal.

We show herewith a photograph of an automobilized railway.

## HANDLING DIRT OUT OF DEEP PITS AND CELLARS.

More and more are light rotary steam shovels used for digging cellars and other small but relatively deep pits. But the use of such shovels would be considerably increased were more thought given to methods of hauling away the dirt more rapidly and more economically.

A small pit is not a good place to get into and out of rapidly with wagons. Besides, a snatch team or hoisting engine is usually needed to pull out the heavy loads. We wish to suggest a few methods of helping such a steam shovel to increase its output, while at the same time reducing the cost of hauling.

Method No. 1: This consists in using a clamshell bucket and a derrick to deliver from a pile of loose dirt in the pit to a hopper above the street level. From the hopper the dirt is loaded into dump wagons. The steam shovel digs the dirt and dumps it in a pile alongside itself, within reach of the clamshell. The clamshell then has only the job of grabbing up loose earth and putting it in a hopper. A steam shovel operated thus can more than double its usual output, and a clamshell can readily handle the loose earth into a hopper without delays. A wagon is filled from a hopper in about a minute, thus reducing team time in loading, to say nothing of saving in time required to get into the pit and out of it. It is well to provide two hoppers to reduce delays. Two dump wagon bodies can be used for this purpose, but a better device is shown elsewhere in this issue.

Method No. 2: This is the same as the method just described, except that a drag-line excavator is used instead of a clamshell bucket. The earth is pulled out of the pit with a power operated scraper bucket and delivered into a hopper. There are several ways of doing this, which need not be described now.

Method No. 3: The loose dirt stacked up by the steam shovel is dragged by team-operated fresno scrapers to the "boot" of a bucket elevator and thereby delivered into a hopper. With a short haul and operating on loose earth, a four-mule fresno and one driver will move 75 to 100 cu. yd. per day.

Method No. 4: This is the same as the last method, except that the place of the mule-operated fresno is taken by a trench "backfiller." A small gasoline hoisting engine on wheels manipulates a scraper that delivers the dirt to an elevator.

Other combinations of mechanical devices for moving dirt can be used. Our object here is merely to suggest ways of greatly increasing the effectiveness of the small rotary steam shovel for pit digging.

## WELL DRILLING AN OPPORTUNITY FOR ENGINEERS.

Well drilling is an excavating process of a very special nature. It requires special skill and it requires special apparatus. The work of well drilling has therefore become centered in the hands of a few contractor specialists. These men have for the most part received their training beginning as workers in a drilling gang and advancing to drillers and contractors. Their origin and training have hampered them. In particular they are conservative, clinging to the processes and tools they know of, afraid of new processes and, therefore, backward in innovating methods and devices to meet new conditions. They are artisans and not engineers. Their field of work is, therefore, one in which engineering training has opportunity and one in which the financial rewards are not inconsiderable. And the field is one which is enlarging as one may readily convince himself.

Well drilling is very old, as was pointed out in an article in our issue of May 31 by one of the writers for this issue, but the use of mud-ladened water, of cementation and of large casing to great depth are comparatively recent developments in well drilling. These methods have not reached full development technically and herein is one opportunity for the engineer well driller. They are only slowly being applied by the old-style driller and here is another opportunity. In the past well drilling has been employed to tap subterranean supplies of gas, of oil, of salt and of water. These will continue to be the main purposes of the operation, but the field will broaden. One cannot believe that salt is the only water-bourn mineral that can be profitably developed by deep wells. But even if the purposes for which wells are driven be confined to those named the work will extend to new fields with new and variable conditons, and herein arises the opportunity of the man educated in engineering to originate methods that will satisfy the new requirements. One might easily extend the illustration were it necessary. As one of the writers in this issue says elsewhere: "The art of drilling offers a great field with ample financial reward to the young engineering graduate who is willing to go into the derrick and acquire the "feeling" necessary to really judge of the ground drilled and check the work of the driller."

## WHY NOT AN ANNUAL CONVENTION OF "DIRT MOVERS"?

Almost every large class of men engaged in construction work holds an annual convention to discuss new methods and to study new machines. Not even the great army of cement users numbers as many in its ranks as the vastly older army of dirt movers whose first president was Adam. Never but once in its history was all of this army put hors de combat—or mule de combat, for that matter—and that was for the 40 days—or was it longer?—when Noah took to the ark. But when he beached his scow on Mt. Aarat it is reasonably certain that the first constructive thing he did was to grade a level spot to live on.

So from that time to this, working then with a sharpened stick for a plow, working now with tools so multifarious that a book can scarcely list them, the "dirt movers" have been the first on every job, be it the digging of a cellar, the ditching for a water pipe or the grading for a railway.

Now, why, with all these men and all these devices for their service, do not both men and devices foregather once a year? The great success of the "cement show" in Chicago every year demonstrates, we believe, that similar success would attend an "excavation show." Would it not be wise for manufacturers of rock and earth moving devices to begin planning such a show for next winter?

## POINTS IN USING A STEAM SHOVEL FOR TRENCH WORK.

In digging large trenches for sewers, etc., steam shovels are frequently used very effectively. A contractor inexperienced in such use of a shovel will find the following suggestions helpful:

First.—Change the position of the levers that operate the shovel, placing them about 5 ft. outside the shovel-house, on an extension platform built for the purpose. Standing there the operator can see the bottom of the trench even where it is 25 ft. or more deep.

Second.—Remove the traction wheels and mount the shovel on rollers that rest on timbers laid on opposite sides of the trench. The shovel is shifted by means of a cable anchored to a deadman, and operated by the main engines. A 60-ton or 70-ton shovel can be moved on rollers 120 ft. per hour over level ground.

Third.—Ordinarily it is best to excavate a deep trench (18 ft. or more deep) in two "lifts" or benches; working one day on the upper bench, then back up and work the next day on the lower lift.

In the upper "bench" use two 50-ft. I beams as "rangers" to support the "sheeting" of vertical planks. One I beam is placed horizontally on each side of the trench, about half way up the "lift," and jackscrew braces every 20 ft. hold the I beams and sheeting in place. Regular timber rangers and braces are also used, but some of these must be temporarily removed when the shovel is digging out the lower bench or lift, and then it is that the I beams hold the sheeting in place. When the shovel is shifted forward (15 ft. or so), the I beams are fastened to the shovel and moved forward with it, after loosening the jackscrews that hold the I beams apart. It takes about half an hour to shift a large shovel forward 15 ft. on rollers.

## INCREASING THE PERCENT OF DIGGING TIME OF A STEAM SHOVEL.

When a steam shovel has begun work on a cut it will usually not be actually digging dirt more than half the time. The other half is spent in shifting forward, in waiting for cars, taking on coal and water, delays incident to field repairs, etc. In rock work, the cleaning out of large boulders and blockholing or mudcapping add still more to the lost time.

Shifting a large shovel forward about 6 ft. each move, where the shovel is on rails, ordinarily takes about 4 to 5 minutes, but a slow gang may consume 15 minutes, whereas a very rapid gang can make such a shift in 1½ minutes or slightly less. If the cut is shallow, necessitating frequent shifts, it will pay well to "keep tabs on" the time spent in shifting with a view to cutting it down to 2 minutes for the average shift. The pit crew should be trained to work at sprinting speed when moving ties and rails forward, for the total daily output depends materially upon the rapidity with which forward shifts are made. It hurts no man to speed up for a few minutes at intervals. Yet many a pit gang works as deliberately while shifting as if that work were a steady all-day job.

When one stops to consider that the daily cost of a large shovel, dinkeys, cars and men is seldom less than $50 and more often is nearer $100, it becomes evident that it pays to employ a man to time all the operations and delays, noting the cause and duration of all time not actually spent digging dirt. Study of the daily reports made by such a timekeeper will indicate steps to be taken to reduce lost time.

On some classes of work the time lost in moving several hundred feet to start a new cut is a source of unduly great expense. In our next monthly issue we will give some suggestions on ways of reducing the time of moving.

## EDITORIAL PARAGRAPHS.

The self-propelling small drag line scraper trench backfiller is a recent earth moving tool and a most useful and efficient tool. Twenty-five years ago the writer saw in a northern New York City a gang on sewer work using a board "scraper," with handles, directed by one man and hauled by a half a dozen other men pulling on ropes and doing exactly the same kind of work, in exactly the same manner, that the power scraper backfiller does it. Verily, the development of a good idea is a long delayed affair.

It occurs to us to assert that the modern trench excavator ranks as king among tools for strictly special excavating tasks. The steam shovel, dredges, power and horse scrapers of various sorts and most small tools are tools for general excavation. The trench excavator is a tool for digging trenches and for no other purpose, and it is one of the most efficient tools that the earth mover has at his command. Incidentally the largest of these machines weighs upward of 50 tons and is not much smaller than the railway locomotive of not so many decades past.

A bucket ladder dredge designed to handle 300,000 cu. yd. of gravel per month has been put into service by the Yuba Consolidated Gold Fields Co. in California. The steel hull alone weighs 1,000 tons. "Some" dirt digger.

## EXCAVATION AND EMBANKMENT CONSTRUCTION IN BUILDING THE YALE BOWL.

The construction of the great amphitheater for athletic games at Yale University involved 300,000 cu. yd. of excavation and 175,000 cu. yd. of embankment. The bowl, therefore, differs from most modern amphitheaters in being essentially an earthwork structure. It is built in a level plain by excavating the center of the field and using the excavated material to make an embankment around the outside, this embankment forming a complete oval about the playing field. The seat slabs are placed directly upon the earth, making it a structure which cannot fall down. The surface of the playing field is about 27 ft. below the original surface of the ground, while the top of the embankment is about 27 ft. above the original surface of the ground, the promenade around the top being 54 ft. above the playing field.

A wall 4 ft. high surrounds the field. Access to the bowl for spectators is provided by 30 tunnels, each 7 ft. wide by 8 ft. high. These extend from the ground level outside to about midway of the seat bank, and aisles lead up and down the slope from the inner ends of the tunnels. Access to the playing field from the outside is given by two tunnels, one 15 ft. wide by 10 ft. high and suited for entrance of vehicles, steam roller, etc., and the other 10 ft. wide by 8 ft. high and suited only for pedestrians, as it contains stairs, being the only tunnel so constructed. Access may also be had to the playing field by a flight of steps at the foot of each aisle. The outside dimensions of the main structure are 933 ft. by 744 and the structure with its approaches covers an area of 25 acres.

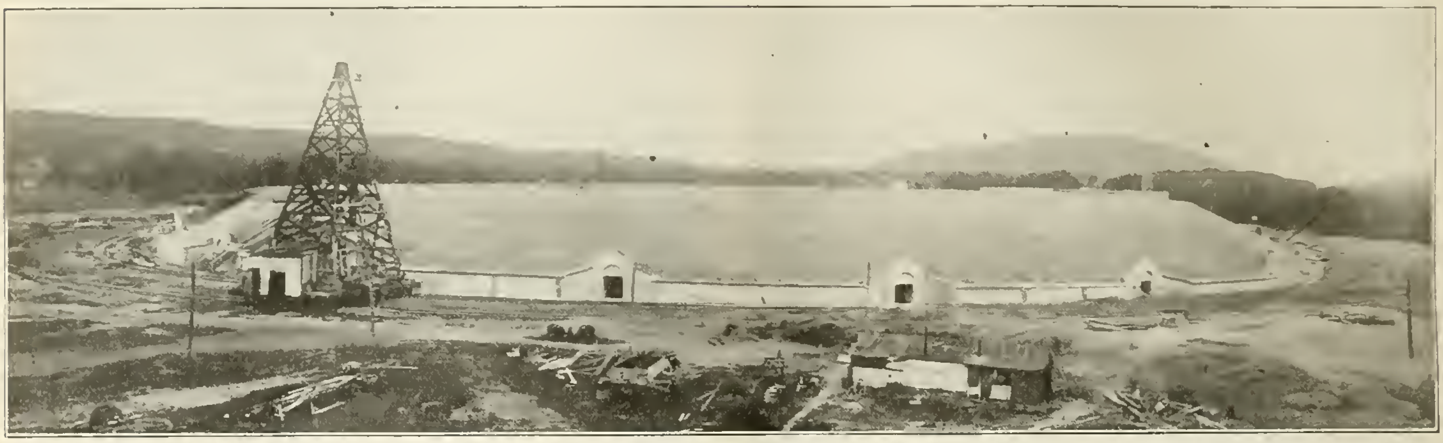
### Excavation.

The following data respecting methods of excavation construction are taken from a paper by Thomas C. Atwood, consulting engineer, in the journal of the Boston Society of Civil Engineers and from data furnished by the contractors, the Sperry Engineering Co., New Haven, Conn.:

The loam which covered the site was first taken off and placed in separate piles of black loam and yellow loam. The depth of the black loam averaged about 10 in. and of the yellow loam about 12 in. Both were of a sandy quality, particularly the yellow loam, some of the latter being but little better than the sandy gravel beneath it.

The gravel was placed in the embankment at first partly by drag and wheel scrapers, but the main dependence for the excavation was placed upon two large drag-line excavators operated from 85-ft. towers which moved on elliptical tracks built closely around the outside of the bowl. These towers operated buckets weighing about 4,500 lb. and having a capacity of about 2 cu. yd. The buckets were hauled in toward the tower by a single cable attached to a drum of the engine and run out by gravity on the main cable, which was pulled up taut by block and fall attached to the head of the tower, and held taut until the bucket had run out as far as desired and then slackened. The other end of the main cable was attached to a post which was moved from time to time so that the bucket might dig from the exact spot desired. Theoretically, a post could have been located at the center of any section of the track which was approximately a circular arc, and all of the material within the sector could have been removed by the bucket, but several practical considerations prevented this from being carried out in the main part of the excavation, although towards the end, when the banks were trimmed by dragging special buckets up the interior slope, this came very near to being the actual layout.

The maximum output of one of the excavators was about 1,500 cu. yd. running 22 hours, while the largest month's work for the two was about 45,000 cu. yd. Considerable experimenting was necessary before the exact design of bucket was found which would load itself in the bottom of the hole, and would travel up the slope without digging into the bank which had already been built. The proper shape was finally found, and the buckets worked very well with only an occasional accidental digging below grade, which usually took place during the night, when the light and supervision were not particularly good. Quite a little difficulty was experienced in digging through the 10 ft. of sandy gravel, which was fairly compact, although the buckets were heavy and equipped with strong teeth. After this was past, however, the digging was very good and the machines worked easily. Most of the excavation outside of the bowl as well as a portion of that inside was made by two Thew rotary steam shovels with ⅝-cu. yd. buckets loading dump wagons.



View of Yale Bowl Earthwork, Showing Tower Drag Line Excavator.

### Embankment.

The specifications called for the embankment above the tops of the tunnels to be rolled in 6-in. layers, and the method of operation was for the drag buckets to make three piles of material between each pair of tunnels, the piles being tent-shaped and usually about 3 ft. high, 8 ft. wide and as long as the bank width. These piles were figured to contain just enough material to make the 6-in. layer, being the most practical way in which to regulate this depth.

As the towers moved along, they were followed up by teams with leveling boards, which leveled off the piles to a fairly uniform surface, and this was thoroughly wet down by water from lines of hose and rolled eight times, each point being gone over four times by a grooved roller and four times by a smooth roller alternately. The rollers weighed about 800 lb. per lineal foot and as a rule required four horses, although occasionally a very heavy team would be found which could operate one for a few days without assistance. One larger roller, which required six horses, was used for a time. Large quantities of water were used. The contract called for 150 gal. per minute, to be run on to the bank night and day.

Below the tops of the tunnels, where rolling was not practicable, the material was watered very heavily, and after the fill had got above the tops of the tunnels, special efforts were made to make sure that the water had penetrated to every portion of the embankment by damming off a section at a time and running all of the water into this section, and punching holes in the bank about 8 ft.

on centers by means of drills or water jets. In this way the whole embankment received a uniform treatment, which could not have been assured otherwise, for the sand was so porous that the water from a 2-in. hose would disappear into the bank within 5 or 6 ft. from the end of the hose, and with operation by the ordinary Italian water boy, it was impossible to tell whether every portion of the embankment had been thoroughly soaked or not.

When the embankment had been carried nearly to its full height, the excess material on the interior slope was dragged up to the top of the bank by heavy timber frames operated by the drag scraper towers in the same manner as a bucket, these frames being about 10 ft. square and having heavy iron plates projecting below the front edge, acting much like a leveling board. They could be made to trim just where it was desired by tightening up the main cable so that they could not go below grade at any point, and they did very good work in shaping up the bank. The final trimming was by hand.

The outer slope of the embankment was trimmed partly by leveling boards operated by power and partly by hand, and was then covered with about 10 ins. of loam, into which strips of turf about 8 ft. on centers were embedded, running parallel to the top of the bank, with the idea that they would help to distribute rain water and prevent it from getting together in sufficient volume to do much damage before it struck another line of turf and was spread out again.

Close View of Yale Bowl and Head Tower of Drag Line Excavator.

The outer slope of the embankment is sloped approximately 1 on 2, except around the portals, where it is about 1 on 1½. These steep places were turfed entirely, but the remainder of the slope was seeded with a mixture of 11½ lb. of red top, 5 lb. of Kentucky blue grass and 20 lb. of white clover. This grew rapidly and seemed to be very good mixture for the purpose, the clover springing up quickly and protecting the grass while it was starting. In this region clover generally dies out after two or three years, while the red top is the native grass and will get a good start by that time.

During the placing of the loam and turf a torrential rainstorm occurred, in which the theory of the strips of turf was thoroughly tested and found to be correct. Small gullies formed between the strips of turf, being at most an inch deep at the upper end and 3 in. deep at the lower end and close together, almost as if a very coarse rake had been dragged down the slope from one strip to another. In no instance did the water dip underneath the turf, and the gullies at the foot of the bank were very little larger than those up near the top. The total amount of dirt washed away was small, and the only repair necessary was going over with a rake to smooth the slope up once more.

## MAJOR RESULTS OF STUMP REMOVAL INVESTIGATION CONDUCTED BY THE UNIVERSITY OF WISCONSIN.

Contributed by Carl D. Livingston, Agricultural Engineering Department, University of Wisconsin.

The land clearing special which has just completed a demonstration tour of Northern Wisconsin has established certain points regarding stump removal which are of interest to contractors who have to do clearing in ditch and railway grading work. The writer, who organized and managed the tour, made a special study of different methods employed by the various co-operators, including horse-power, hand-power and dynamite, each working separately as well as in combination with each other. The following points were established to be good practice in land clearing:

Where the stumps are large it was found that from one-third to one-fourth the amount of dynamite necessary to entirely remove the stumps from the ground would crack them into several pieces so that one or more of them could be pulled. Stumps may be pulled easier and quicker when cracked. The hole left is not nearly so large as when either pulled whole or blown out entirely. The roots are cleaner, are easier to handle, dry quicker and are more easily burned.

On the loams and clays it was found that 20 per cent Red Cross dynamite would do the same work as 40 per cent at a saving of 25 per cent on the dynamite bill. , On the lighter soils the 30 per cent grades did as good work as the high kinds and cost about 10 per cent less. Forty per cent grades on higher are only needed on dry sands.

Electrical blasting was found to be quicker to operate, and far more safe than the old cap and fuse method. By the use of a blasting machine many charges may be detonated at the same time, either under the same or different stumps. This method enables the charge to be placed where they are most needed. The holes left are usually smaller and the cost is not greater when the results are taken into consideration.

Stump pilers are necessary to efficient land clearing where mechanical pullers are used. When they are equipped with automatic tripping devices piling may be done at the same time as the stumps are being burned. When stumps are dropped on a burning pile a more complete burn is secured; some dirt may be left on the roots and they may be much greener and still burn. The jar of falling stumps is like continually poking a grate fire.

Though essentially a land clearing demonstration, exhibitions of ditch blowing with dynamite were given. Beyond all doubt, explosives are extremely valuable in certain kinds of ditching work. No matter how wet, brushy or stony the ditch line may be, if sticks of 60 per cent straight nitroglycerine dynamite can be located within

18 in. of each other in wet ground a serviceable open ditch can be made by the detonation of only one cartridge.

## SOME NOTES ON USE OF MUD-LADENED WATER IN DRILLING WELLS.*

Water can easily be ladened with any clayey material that will remain in suspension for a considerable period of time. Such mixture may weigh 33 per cent more than the same volume of clear water, or give a head of 57 lb. per 100 ft., or a margin of safety of 14 lb. on each 100 ft. of depth.

**Requirements.**—It is fundamental when drilling by the hydraulic rotary method that a circulation of mud-ladened water, such as described, be maintained from the surface down through a vertical rotary drill pipe and bit, and up between the drill pipe and the wall of the well back to the surface. Moreover, at all times, the mud pressure at any point in the well must exceed the pressure in the strata penetrated at that point, thus excluding all gas, oil, and water as they are encountered. The proper use of mud-ladened water gives a means of drilling wells and keeping them in a state of equilibrium until screens can be set in productive horizons and casing set and cemented in. Thus complete control is given in bringing them to producing. As a practical matter, in a drill hole 1,500 ft. deep a good mud will not settle in a week sufficiently to prevent a drill pipe from being run freely to bottom, and the mud pump from starting circulation, so rotating and drilling may be resumed. Also, such mud will not stick or freeze in a drill pipe if left in 24 hr.

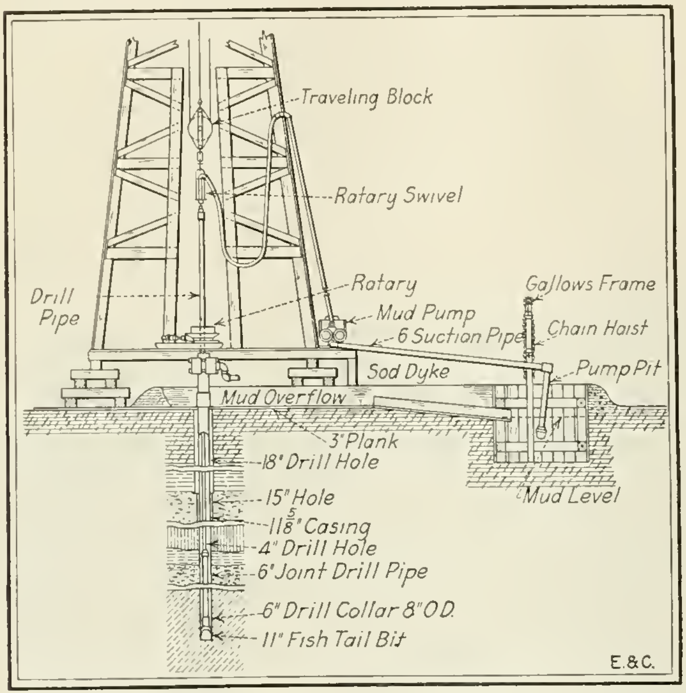


Fig. 1—Rotary Drilling Outfit for the Use of Mud Ladened Water.

**Mud Tests.**—Mud can be best tested by weighing. I used a common market beam scale (without pan) having a capacity to weigh 50 lb. by ounces, and a common galvanized iron bucket in which to weigh the mud. Four equally spaced ¼-in. holes were punched under the top rim to furnish level marks to fill to.

The bucket is first hooked on under the beam, the poise brought to zero, and the whole balanced by counterweighting. The bucket is then filled to the level holes with clear water and its weight taken and noted. It may be, for instance, 18 lb. The poise is again placed at zero and more counter-weight added to balance the clear water. This water is then thrown out and the bucket filled with mud, and the poise, when balanced on the beam, will indicate the additional weight of the clayey material in suspension over that of the same volume of clear water. The bucket may be filled with mud as many times as desired and weighed without further adjustment. If the additional weight found at any time should be 6 lb. it would indicate the mixture weighed about 33 per cent more than the same volume of clear water. If a good working mixture is found to be 5 lb. of additional weight per bucket of mud, and in drilling it increases to show 6 lb., clear water may be slowly added until the weight drops to 5 lb. or a little less. This weighing is simple and practical and is no fad. It is just as necessary for the driller to have a scale and know the weight of the mud he is using as to have a gauge to show the mud pump pressure. A well can be drilled without a pump gauge, or scales to weigh the mud, but it can be drilled safer and in better time if both measurements are intelligently used.

**Preparations for Drilling.**—The drilling apparatus, Fig. 1, being all ready, a mud pump is started and the thin water pumped out of the pump pit. The latter is then filled with mud to above the ground or tidewater level, so there can be no chance of the inflow of clear water thinning the mud. A circulation is then established, by operating a mud pump, from the mud pit through the drill pipe and bit, back to the pit, and continued until the whole content of the pit is properly tempered.

**Drilling.**—The rotary is started and the drill begins at the surface to make hole. To a depth of 15 ft. I used an 18-in. fishtail bit with 6-in. shank and 6 by 10-in drill collar (12 in. O. D.) on one joint of 10-in. pipe, followed by a string of 6-in. drill pipe. A 16-ft. length of galvanized, corrugated, culvert pipe was used for the conductor pipe and driven into place. The top was belled out and spiked to the 3-in. surface planking.

The 18-in. fishtail bit being replaced by a 15-in. bit, the drilling is continued through the conductor pipe and the mud kept close to some standard weight. The large drill collar (12 in. O. D.) on a 10-in. joint of pipe in a 15-in. hole retards to some extent the rate of drilling in unconsolidated material. On the other hand, its use compels the drilling of a round straight hole that requires no reaming before setting a string of casing; also, its use seems more effectively to plaster the drill cuttings and mud into the walls of the well in puddling off the porous strata as encountered, and so preventing loss of mud. In pulling out, there is no dragging or turning of the drill pipe, and in running in, the bit goes plumb to bottom.

As a matter of experience, it had been found that a well drilling in soft sandy material with a 15-in. fishtail bit, followed by a 6-in. (about 7½-in. O. D.) drill collar and 6-in. pipe, was easily deflected by concretions or pieces of wood, resulting in crooks or humps in the hole. In extreme instances, after pulling out and starting in with a sharp bit such crooks or humps would form enough obstructions so that the bit would not spud past them, and upon rotating a new hole would form, side-tracking a considerable depth already drilled, which was consequently lost. Furthermore, it was often necessary in running back into crooked holes to start pumping and rotating before getting to bottom, because materials which were scraped off the walls of the well and carried down made a bridge or stoppage. In any case a crooked, humped, or deflected hole requires the use of a rotary shoe or reamer to size the hole down before a string of casing can be run in and set.

Just before pulling out the drill pipe, the mud in the pump pit and the surface circulation should be stirred up, so as to weight the descending mud in order that the drill string will uncouple dry. In pulling out, mud must be frequently pumped into the well so that the "head" of mud, or pressure from within the well, will meet the fundamental requirement before stated. After running a drill pipe to bottom or to a bridge in the hole, no attempt to start a circulation for drilling should be made until the surface mud is first circulated and brought to a proper temper.

In case of a heavy rain it is best to stop drilling and pumping, and pull up off bottom before the circulation thins out. With a good mud there is no danger of "freezing in" even if the drill pipe is left in over night. A circulation should be maintained only when rotating. Pump pits and mud circulation must always be protected against surface drainage and rise of tide.

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*Extracts from a paper by I. N. Knapp, Ardmore, Pa., in Transactions, American Institute of Mining Engineers.

**Action of Water and Mud.**—Clear or turbid water flowing on the surface will erode unconsolidated materials, the rate depending upon the velocity or grade and upon the volume. It has also a solvent or slacking action on earthy matter. If such flow was, for instance, through a shallow ditch it might perhaps cause the banks to cave sufficient to make a meander outside of the dug channel. If, however, clayey matter is added to the flowing water the erosive action weakens until a point is reached where erosion practically ceases and the suspended matter will begin to build up and protect the loose material. The solvent action also will be very much weakened and in such a case a shallow ditch in loose material will tend to keep its shape as dug. Clear water will continue to sink in sand or porous material in quantity for an indefinite time. Turbid water will gradually render sand or porous material impervious, but the suspended matter will be carried in and deposited in the sand to a considerable depth. A good mud (or mud-ladened water) will render sand or porous materials impervious almost instantly and the penetration of the mud is small.

**Open Hole.**—With a good mud and skillful working there was no difficulty in drilling 700 ft. of 15-in. open hole before setting the first string of casing ($11\frac{5}{8}$ in.). The drill passed through several layers of fine water sand, having a total thickness of perhaps 200 ft.; through 100 ft. of sandy materials and shells, and 400 ft. of clays and sticky mud. Starting with the storage pit full of thick mud, it was not found necessary to mix any additional mud to reach a depth of 700 ft., under the conditions named. As a matter of experience, I drilled 1,880 ft. in depth of $8\frac{1}{2}$-in. hole with the rotary, using mud, going through three well-known water-bearing loose sands with strata of clays, shales, shell beds and some sheets of rock, and then set a string of $6\frac{5}{8}$-in. casing, 60 ft. of 14-in. O. D. drive pipe being all the other pipe in the hole. There was no caving and but little loss of mud. The work was done in day time only and the drill pipe was many times left in over night with no sign of sticking or freezing.

**First String of Casing.**—This should set so that the top coupling will come just above the 3-in. surface plank, and so that a drilling nipple can be screwed into it. This nipple should have a 6-in. hole cut in its side, so as to bring the overflow from the well as high up as possible under the derrick floor. A wood block is fitted to match over the side hole and a 6-in. pipe flange bolted to the latter and the whole clamped to the nipple. A 6-in. pipe is connected (with nipples and two elbows to make a swing) to the flange to carry the mud circulation of the derrick to an overflow just back of the place where the driller stands at the hoisting-drum brake. The advantages in bringing the overflow up to this point are that it can easily be seen by the driller and that there is a better chance for getting samples of cuttings than from a ditch. Flash boards may be placed across the trough to act as riffles to catch the sand. A convenient size for the trough is 8 by 20 in. inside and 48 ft. long. This is blocked up as high as possible and still permit it to carry the mud from the pipe overflow into the end of a sand settling pit about 45 ft. from the derrick. This pit is made by banking sod 30 in. high around a plot about 10 by 30 ft. From its opposite end an 8 by 10 in. trough (made of 2 by 10 by 16 plank) carries the mud back to the pump pit.

## ECONOMIC ADVANTAGE OF SUBSTITUTING LARGE SINGLE FOR SMALL DUAL MOTOR TRUCK TIRES.

The following economic advantages of substituting large singles for 3, $3\frac{1}{2}$ and 4-in. dual rear tires were enumerated in an address before the Society of Automobile Engineers by W. H. Allen, Manager Truck Tire Production, B. F. Goodrich Co., Akron, O.:

(1) Saving in tire cost ranging between 8 and 15 per cent.

(2) Saving in wheel cost. The reduced wheel cost is attributable to the narrower felloe stock and wheel rim required, together with whatever saving may be made in connection with wheel design.

(3) Saving in cost of handling and applying one tire instead of two.

(4) Saving in wheel, tire and rim weight resulting in possible greater operating economy and relieving unsprung weight.

(5) Larger tire that will adapt itself better to uneven road surfaces, compensate for excessive road crown, carrying its burden as a unit rather than alternately on one narrow tread and then on the other.

(6) Greater ease of fitting non-skid chains.

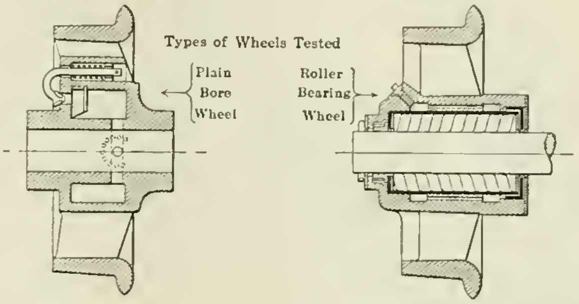
(7) Better tracking with front wheels.

(8) Usually greater height of rubber tread, thus providing greater cushioning properties with consequently increased tire and vehicle life.

(9) Decreased strain on axle and wheel bearings as result of decreased leverage obtained by the narrower wheel tread.

## FRICTION TESTS OF ROLLER BEARINGS AND PLAIN BEARINGS FOR MINE CARS.*

This particular test was made at the Greensburg Coal Co.'s mine at Greensburg, Pa., in co-operation with the H. C. Frick Coke Co., which was represented by its chief mechanical engineer, C. E. Huttelmaier. The test was run on the main haulage road underground to determine the saving in tractive effort of mine cars equipped with roller bearings as compared with mine cars equipped with plain bearings under identical conditions of operation. The drawing shows the two forms of bearings; all other conditions were made as nearly equal as possible.



Plain and Roller Bearing for Mine Cars.

The following average values were found:

| Type of Bearings. | Average Grade. Per Cent. | Test No. | Average Drawbar Pull, Pounds. | Average Speed. Miles per Hour. |
|---|---|---|---|---|
| Roller | 2.4 | 4 | 4,410 | 5.75 |
| | | 5 | 4,350 | 6.56 |
| | | 6 | 4,280 | 5.56 |
| Plain | 2.4 | 1 | 5,250 | 5.70 |
| | | 2 | 5,070 | 5.78 |
| | | 3 | 5,190 | 5.30 |
| Average of tests 4, 5 and 6 | | | 4,347 | 5.98 |
| Average of tests 1, 2 and 3 | | | 5,170 | 5.59 |

To correct these figures for grade, 20 lb. per ton per 1 per cent must be subtracted from the above drawbar pull. For the train weight of 71.5 tons and the average grade of 2.4 per cent the correction amounts to 3,432 lb. for each train.

The corrected tractive effort for the roller-bearing cars therefore amounts to:

$$4,347 - 3,432 = 915 \text{ lb. at } 5.98 \text{ miles per hour}$$

and for the plain-bearing cars:

$$5,170 - 3,432 = 1,738 \text{ lb. at } 5.59 \text{ miles per hour}$$

Expressed in pounds per ton this means for the roller-bearing cars 12.8 lb. per ton and for the plain-bearing cars 24.3 lb. per ton.

Disregarding the slight difference in speed, the saving in drawbar pull in favor of roller-bearing cars therefore amounts to 47.25 per cent.

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*Extract from a paper by P. B. Liebermann in Transactions American Institute of Mining Engineers.

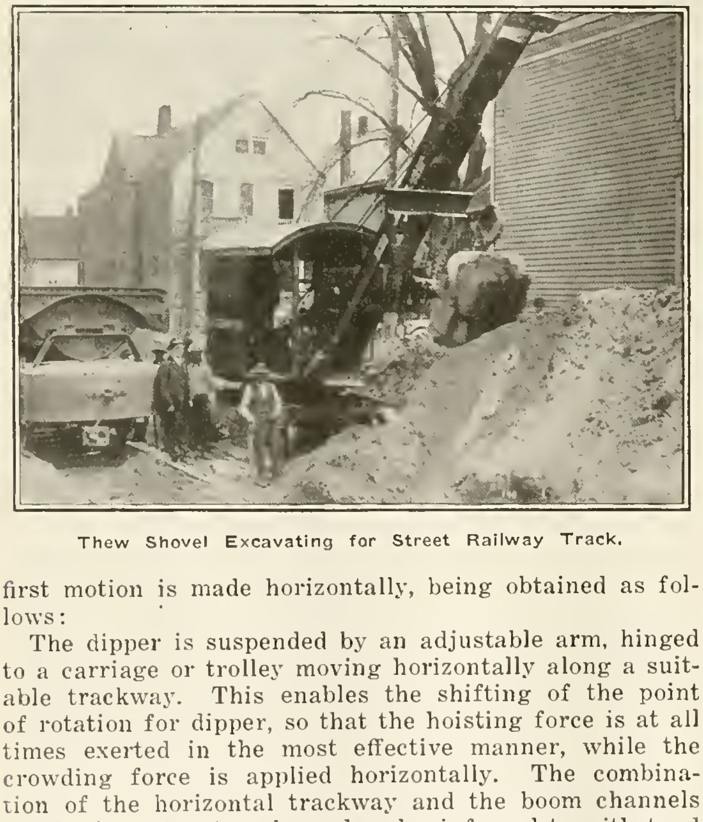
## INEXPENSIVE EXCAVATION BY CLEVELAND RAILWAY CO.

(Contributed.)

In these days of increasing prices and scarcity of capital every operating company is on the lookout for ways and means in which to effect the most economical and labor-saving operations. The tests made on some excavation work done by the Cleveland Railways Co. this summer indicate that this company is reaping the benefit of such economies. In building its 79th St. line, the railway company had to do a considerable amount of excavation for which it employed the electrically driven Thew automatic shovel illustrated herewith.

This shovel is of the horizontal crowding motion type and has several other features of interest. It weighs 13 tons, has a dipper with a capacity of ⅝ cu. yd. and a clearance height over the house of 12 ft. 2 in. It is mounted on regular car wheels on which it travels on the car tracks and in addition is equipped with a set of auxiliary traction wheels, 33 in. in diameter, and 15-in. tread, which permits it to run under its own power over the ground, pavement, or wherever it is desired to take it.

The horizontal dipper crowding motion utilized is said to be particularly adapted to the application of electric drive because of the ease of control and power demands. In excavating material with a shovel it is necessary first to crowd the dipper forward into the material, then to hoist it upward through the material. In this case, the first motion is made horizontally, being obtained as follows:



Thew Shovel Excavating for Street Railway Track.

The dipper is suspended by an adjustable arm, hinged to a carriage or trolley moving horizontally along a suitable trackway. This enables the shifting of the point of rotation for dipper, so that the hoisting force is at all times exerted in the most effective manner, while the crowding force is applied horizontally. The combination of the horizontal trackway and the boom channels results in a structure braced and reinforced to withstand the severe strains which the boom is called upon to endure. The trolley motion is controlled by a lever. This lever is further connected to a trip rod which is operated automatically when the trolley reaches the limit of its motion in either direction. The crowding motion enables this type of shovel to be advantageously employed for very shallow excavating operations.

The entire motive power for traction, hoisting and swinging consists of one 20-h.p. Westinghouse compound-wound 550-volt direct-current motor with a starting and reversing control equipment. The motor operates at approximately constant speed, the various motions being controlled through suitable friction and gears. The current is usually admitted to the shovel through a flexible insulated cable connected to a switch on the truck frame and transmitted through copper rings to brushes suspended from the swinging turntable.

The use of one motor appears to be a particularly desirable feature for reducing the initial cost and affording greater flexibility of action in the frequent reversals of the various operating motions; it also means the operation of three levers instead of three separate controllers, and a gain in time over starting and stopping three separate motors. It is distinctly a one-man machine.

The boom is of the jackknife type with an adjustable section that can easily be located, allowing the shovel to pass under the trolley wire, without interfering in any way with the efficiency of its operation. The shovel swings through a complete circle, delivering the excavated material at any desired point.

A buffer is furnished which takes up the shock that occurs when the shovel strikes a hard piece of excavation. This allows the shovel to be released and relieves the whole machine from the strain to which it would otherwise be subjected.

The cab is cut away so as to allow plenty of room for passing cars, a feature of particular importance when used on street railway work.

The illustration shown herewith affords an excellent idea of the class of work being done by the Cleveland Railways Co. and the manner in which the shovel is operated, while the following data obtained through the courtesy of Mr. J. J. Stanley, President, and C. H. Clark, Engineer Maintenance of Way, show the cost of the entire operation.

LOADING.

| | |
|---|---|
| Shovel man @ 40 ct. | $ 4.00 |
| Four laborers @ 21 ct. | 8.40 |
| Current, oil, repairs, etc. | 1.50 |
| Loading cost per day | $13.90 |

HAULING.

| | |
|---|---|
| Four men @ 26 ct. | $10.40 |
| Four men @ 19 ct. | 7.60 |
| Two men @ 30 ct. | 6.00 |
| Hauling cost per day | $24.00 |

DUMPING.

| | |
|---|---|
| One foreman @ 30 ct. | $ 3.00 |
| Six laborers @ 20 ct. | 12.00 |
| Dumping cost per day | $15.00 |

LOADING, HAULING AND DUMPING.

| | |
|---|---|
| Cubic yards loaded in 10 hr. May 8 | 540 |
| Cost of loading per cubic yard | 2.6 ct. |
| Cost of hauling per cubic yard | 4.4 ct. |
| Cost of dumping per cubic yard | 2.8 ct. |
| Cost of loading, hauling and dumping | 9.8 ct. |
| Lineal feet excavated on this work | 2,700 |
| Number of 10-hr. shifts operated | 12 |
| Lineal feet excavated per 10-hr. shift | 225 |
| Cubic yards loaded (place measure, per 10-hr. shift) | 450 |
| Average loading cost, 450 yd. @ $13.90 | 3 ct. per cu. yd. |
| Average hauling cost, 450 yd. @ $24.00 | 5½ ct. per cu. yd. |
| Average dumping cost, 450 yd. @ $25.00 | 3⅓ ct. per cu. yd. |
| Average loading, hauling and dumping cost | 11⅔ ct. |
| Length of haul, approximately | 6 miles |
| Average HP. used in moving shovel | 15.0 |
| Maximum HP. used in moving shovel | 20.2 |
| Average HP. used in operating shovel | 11.7 |
| Maximum HP. used in operating shovel | 43.6 |

The shovel is built by the Thew Automatic Shovel Co. of Lorain, O., and the electrical equipment by the Westinghouse Electric & Manufacturing Co. of East Pittsburgh, Pa.

## METHOD OF KEEPING COSTS ON THE PIUTE IRRIGATION PROJECT EARTH DAM.

Contributed by Jos. Jenson, Salt Lake City, Utah.

Much has already been said and written on cost keeping in connection with construction work. In part, this has been good and timely; in part it has been "red taped" to a bewildering tangle, and in part has been devised with particular reference to the convenience of an office force and has been illy adapted to field requirements and conditions. Nearly all has assumed the services of a cost data expert. The only excuse for offering at this time an additional chapter on this subject, is that it is believed that the system herein outlined contains certain elements of simplicity, that it is direct and accurate, and can be handled with entire success by any foreman of average intelligence, and that it has stood the test of actual practice. The particular piece of construction which the writer has selected with which to illustrate the application of this system of cost keeping is the storage dam of the Piute Ir-

LABOR SEGREGATION ON PIUTE STORAOE DAM FOR MONTH OF OCTOBER, 1913

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 29 | 30 | 31 | Total Days | Rate Per Day | Amount $ | cts. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DRY FILL | | | | | | | | | | | | | | | | | |
| Trap Teams | 12 | 12 | 12 | 12 | 0 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 324 | $4.70 | $1,522 | 80 |
| Plow Teams | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 54 | 4.70 | 253 | 80 |
| Dump Wagons | 21 | 21 | 21 | 20 | 0 | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 19 | 544 | 4.70 | 2,526 | 80 |
| Plow Shakers | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 54 | 2.70 | 145 | 80 |
| Dumpers | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 54 | 2.70 | 145 | 80 |
| Wheel and Tongue Scrapers direct onto dam | 6 | 5 | 6 | 3 | 0 | 5 | 5 | 5 | 6 | 2 | 7 | 5 | 4 | 99 | 4.70 | 465 | 30 |
| Scraper Loaders | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 0 | 0 | 1 | 2 | 30 | 2.50 | 75 | 00 |
| Teams Digging Trap Pits | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 0 | 0 | 0 | 16 | 4.70 | 75 | 20 |
| Laborers Building Traps | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 0 | 0 | 0 | 5 | 3.00 | 15 | 00 |
| | | | | | | | | | | | | | | | | $5,225.50 | |
| HYDRAULIC FILL | | | | | | | | | | | | | | | | | |
| Teams Moving and " Sluice Plant | 2 | 2 | 1 | 2 | 1½ | 1½ | 1½ | 0 | 0 | 0 | 0 | ½ | 0 | 20 | $4.70 | $ 94 | 00 |
| Mechanics " " " " " | 5 | 4½ | 4 | 4½ | 4½ | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 46 | 3.00 | 138 | 00 |
| Laborers " " " " " | 4 | 3 | 1 | 1 | 1½ | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13½ | 2.70 | 36 | 45 |
| Sluicing Laborers | .... | .... | .... | .... | .... | .... | .... | 3 | 3 | 3 | 2 | 1½ | 2 | 45½ | 3.00 | 136 | 50 |
| " " | .... | .... | .... | .... | .... | .... | .... | 2 | 2 | 2 | 2 | 1½ | 2 | 45½ | 2.50 | 113 | 75 |
| | | | | | | | | | | | | | | | | $ 518.70 | |
| ROCK EXCAVATION FOR SPILLWAY | | | | | | | | | | | | | | | | | |
| Miners | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 1 | 0 | 0 | 15 | $3.50 | $ 52 | 50 |
| Mucking Teams | .... | .... | .... | .... | .... | 1½ | 0 | 0 | 5 | 8 | 5 | 8 | 0 | 121 | 4.50 | 544 | 50 |
| " Laborers | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 3 | 3 | 0 | 38 | 2.50 | 95 | 00 |
| " " | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 3 | .... | 35 | 3.00 | 105 | 00 |
| | | | | | | | | | | | | | | | | $ 797.00 | |

Fig. 1.

rigation project built by the State of Utah on the Sevier River in the south central part of the state.

The dam consists essentially of an earth enbankment 95 ft. high, containing practically 500,000 cu. yd. of earth, and auxiliary structures such as drainage tunnel, head gates, spillway, etc. The larger portion of the earth was put in by the hydraulic method, and is referred to in the sheets herewith as the "Hydraulic Fill." A considerable portion was hauled in by team and is referred to as "Dry Fill." All the work incident to the construction, except the outlet tunnel which was done by contract, was done by force account.

The organization of the working force was the simplest possible. The writer, as Engineer in Charge, had entire general charge of all operations and exercised general supervisory power. Our general foreman or labor superintendent had charge of all the men. Under his direction one or more reliable or trustworthy laborers was appointed as "gang leader" for each group into which the work naturally divided the force. The "gang leader's" function was that of a pace-setter rather than that of a directing foreman. No clerks nor special time-keepers were employed on the work. There was but one man, namely, the general foreman or labor superintendent, whose duties did not require him to do his regular day's labor. This simple organization proved to be quite adequate to the handling of a force of men numbering from eighty to one hundred. It should, probably, be stated at this point that white labor only was used on the job.

The general foreman is the official time-keeper, and is required each day to make up the labor segregation. This labor segregation is made on a regular time book sheet, in fact is made up on pages of the regular time book in which the individual time is kept. This labor segregation is compared at the end of each shift with the individual time sheet, e. g., the total number of team-days, for the day shown by the individual time sheets must equal the total number of team-days shown on the labor segregation sheets, etc. It is the firm conviction of the writer that this function should be a part of the duty of the general foreman, who is most intimately acquainted with the day's proceedings, rather than to leave the matter to a special time-keeper, who is usually a clerical assistant, and is not completely cognizant of the details of the day's work. If the duties of time-keeper and that of making up the labor segregation sheet are too arduous, in connection with the general foreman, it is better to allow him relief in other matters rather than to turn over to a subordinate the duties of time-keeper. A page of the regular labor segregation sheets is shown by Fig. 1. The accuracy with which this sheet is kept constitutes the vital element in the whole system, and is, therefore, put in the hands of the person most intimately acquainted with the day's work, namely, the general foreman.

At the end of each month the time book for the month, including the labor segregation sheets, is turned over to the general superintendent, and the matter of computing the labor costs for the month is merely a matter of extensions and additions. It is obvious that the total labor cost should equal the total payroll, as shown by the regular time sheets, and this will serve as a check on the correctness of the former.

The keeping of materials and equipment costs is handled quite as simply: All materials or equipment used, whether by direct purchase or transfer from other parts of the projects, are ordered on blanks for this purpose.

COST DATA ON PIUTE RESERVOIR DAM FOR THE MONTH OF OCTOBER, 1913

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hydraulic Fill | | Dry Fill | Rock Excavation for Spillway | Riprap | | Camp Maintenance | Labor Superintendence | Total Payroll | Engineering and General Supervision |
| MONTH | Moving Plant to West Side | Sluicing Operations | | | Upper Slope | Lower Slope | | | | |
| October, 1913. | | | | | | | | | | |
| Total Labor Account | $231.45 | $373.25 | $5,303.68 | $ 946.40 | $97.00 | $262.70 | $23.25 | $124.00 | $7,361.73 | $324.40 |
| Materials and Equipment | 227.37 | 30.20 | 133.78 | 365.35 | | | | | | |
| Distributive Costs, including columns 8, 9 and 11 | 28.50 | 28.50 | 318.85 | 19.00 | | 81.00 | 4.20 | | | |
| Total Costs | $487.32 | $431.95 | $5,756.31 | $1,330.75 | $97.00 | $343.70 | | | | |
| Total Cubic Yards | | 8,000 | 14 000 | 1,550 | 170 S.Yds. | 1900 S.Yds. | | | | |
| Unit Costs | 6.1c | 5.4c | | | | | | | | |
| | 11.5c | | 41.2c | 85.8c | 57.1c | 18.0c | | | | |

Note—Sluicing operations were discontinued Sept. 20th to Oct. 9th on account of moving from East to West side of Damsite.

Fig. 2.

These are made out in quadruplicate—one copy sent to the party furnishing the goods, one sent to or retained by the paying office, and two sent to or retained by the superintendent of construction. On the reverse side of the order blank is printed a consignment receipt. Upon receipt of the goods ordered the receiver fills out the two copies in the possession of the superintendent of construction, as shown, one copy sent to the paying office as its warranty for paying the bill, the other copy filed with the superintendent to be used for making up his cost data summary. The material is charged to the particular part or parts of the structure at the time of receipt. As the material is checked out for use, if there should be any transfer to any other parts or subdivisions of the work, the original charge is not charged, but the transfer is recorded in a memorandum book kept for that purpose, and the charges equalized on the next succeeding receipt of goods, so that, while each consignment receipt may not be strictly accurate, the aggregate at the end of a six or twelve months' period will be practically correct.

At the end of each month the costs kept in the manner above explained are summarized, as shown in the specimen report, Fig. 2. This form is made up for each individual report in order to avoid a more complex and cumbersome blank which would serve for the entire construction period. With these monthly summary blanks it is a very simple matter to make at any time a complete, up to date summary, or a final statement of segregated costs at the end of the construction period. The head form, specimen lines, and totals of the final cost data sheet on the structure used for illustration of this writing, is shown by Fig. 3.

PIUTE RESERVOIR AND STORAGE DAM
Monthly and Final Tabulation of Costs

*By Jos. Jensan,*
*Engineer and Gen'l Superintendent.*

| | General Classification | | | | | | Labor and Materials Segregated | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| DATE | Engineering and Gen'l Superintendence | Total Materials and Equipment | Total Labor | | Gen'l Miscellaneous Expenses, Examination of Materials and Damsite, Etc. | Purchase of Land for Reservoir and Water Rights | Other Tunnel Approaches and Gates | Temporary Diversion Works and Clearing Damsite | Pipeline and Auxiliary Structures | Power, Pumping and Sluicing Plant | Core Trench and Puddle Wall | Dry Fill | Hydraulic Fill | | Riprap | | Spillway | Permanent Buildings | Camp Maintenance | Miscellaneous |
| | | | Force Account | Contract | | | | | | | | | Sluice Boxes and Trestles | Operating | Upstream Slope | Down-stream Slope | | | | |
| 1910 June | 286.57 | 128.55 | 3584.58 | 1499.18 | 25.00 | | 2.00 | 172.14 | | | 1499.18 | 1980.62<br>10.00 | | | 423.82<br>29.10 | | 1008.00<br>87.45 | | | |
| 1913 October | 324 40 | | 7361.93 | | 64.63 | | | | | | | 5400.68 | | 616.70 | 97.00 | 262.70 | 961.60 | | 23.25 | |
| 1914 April | 126.68 | 36.36<br>201.29 | 7333.47 | | | | | | | | | 36.36<br>5315.07 | 913.20<br>22.73 | 502.50<br>172.45 | 541.55 | | | | 61.15<br>6.11 | |
| Total Labor ...... | 21073.60 | | 184055.68 | 18894 50 | 7853.58 | | 17181.47 | 3872.68 | 9778.50 | 1424.94 | 35854.07 | 78872.50 | 4154.17 | 15932.31 | 12890.77 | 2063.70 | 16725.73 | 605.01 | 2215.65 | 788.85 |
| " Materials ... | | 53183.71 | | | | 37840.50 | 5540.65 | | 18903.26 | 8796.26 | 6785.30 | 928.29 | 4641.17 | 3842.26 | 1613.18 | | 4053.16 | 530.67 | 516.35 | 340.99 |

Fig. 3.

## DIAGRAM FOR COMPUTING EARTHWORK.

Contributed by M. P. Taylor, Des Plaines, Illinois.

The accompanying diagram gives a convenient method of computing earthwork, being especially intended for use in making estimates from the center line profile. It has been used by the writer in drainage work particularly,

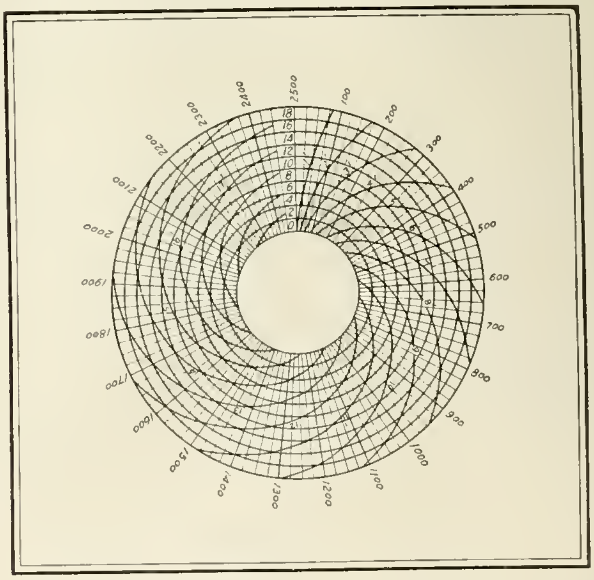


Diagram for Computing Earthwork.

in figuring quantities on open ditch and levee work, being more convenient in some respects than the use of tables.

The diagram shown gives the quantities for 100 ft. stationing for a section of from 0 to 20-ft. base, and from 1 to 16-ft. height or depth. Slopes were figured at 1½ to 1.

Distances along the radii represent the dimension of base of section, and the irregular curved lines show the depth of cut or height of fill. Quantities in cubic yards are given along outer circumference of diagram. To obtain quantity for any given base and cut or fill, extend radius through point of intersection of lines representing these two factors, and read yardage in cubic yards directly from circumference.

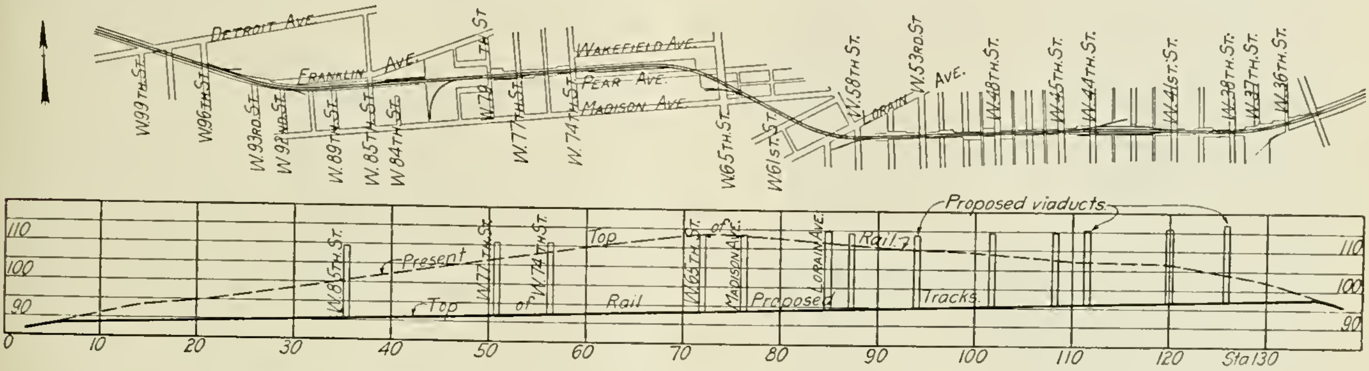
## HYDRAULIC EXCAVATION OF A LARGE CUT IN CLEVELAND, OHIO, GRADE CROSSING ELIMINATION.

Contributed by C. E. Drayer, Cleveland, Ohio.

Seven hundred and fifty thousand cubic yards of earth excavation will be handled by hydraulic methods in eliminating grade crossings of the New York, Chicago & St. Louis Railroad Co. for a distance of about 2½ miles in Cleveland, Ohio. Among the conditions that favored adopting this method were economy, the nature of the soil to be handled, the location and shape of the spoil bank, ease in draining off water at the spoil bank, availability of ample water supply and avoidance of serious interference with the traffic of the railroad as well as that of the many streets crossed.

A four track road bed will be built the entire distance. The earth in the road bed prism will be removed in two cuts. After the first cut is made a double track will be laid in it and the tracks on the present grade removed.

Preliminary test borings showed that the material to be removed is sand with a slight mixture of clay. The bottom of the cut will be in quicksand, which is very wet and will require an extensive system of drainage to secure a solid road bed. The character of the material not only is favorable to hydraulic grading but it would render the operation of the steam shovel difficult and unduly expensive.



Plan and Profile of Cleveland Grade Crossing Elimination by Hydraulic Excavation.

Excavation will be by Hendy ball-bearing hydraulic monitors with an inlet diameter of 11 in. and discharging water under 100 lb. pressure through nozzles ranging from 2½ to 4 in. in diameter. The water with its earth content will be collected by sumps from which it will be picked up by dredging pumps and sent to the waste bank in Walworth Run through a discharge line of 12-in. spiral riveted pipe. The dredging pumps will be 10-in. single suction, direct connected to 514 R. P. M., three-phase, 60-cycle, 2,300-volt variable speed motors. The pumps are designed to discharge 4,000 gal. per minute against a head of 125 ft. It is intended to distribute three pumps along the discharge line as the work advances and to use them as boosters. This way was considered better than to install sufficient power at the end of the line to maintain the necessary velocity through the entire pipe which will have a maximum length of 11,000 ft. The pumping unit at the face of the cut will be moved along on skids as the work advances.

Water and electric power will be bought from the city. The city has about completed a new pumping station which will have a capacity considerably in excess of its present needs. A portion of this excess capacity will be devoted to supplying the water necessary for the monitors through 20-in. spiral riveted pipe from the high pressure main at West 41st St., which is in the easterly section of the grade crossing elimination zone. Power for the motors driving the pumps will be supplied by the Municipal Electric Light plant.

To find a location for the disposition of the excavation material was a difficult problem, much simplified by the adoption of the hydraulic method of grading. At the east end of the grade crossing elimination zone the Nickel Plate enters Walworth Run, a narrow, irregular valley traversed by the Big Four railroad. A track to carry steam shovel excavation into the Run would have been on a 3.4 per cent grade and unable to reach sufficient area required for the waste. Some 15 or 18 years ago a large sewer was built in the Run to care for the natural runoff and sewage. Since then the valley has remained useless and unsightly as well as unsanitary in that neglected ponds of water became breeding places for mosquitoes and swimming holes for the youth of a not high grade community. Authority from the property owners was obtained by the city to fill the valley, with the result that valuable industrial property adjacent to the Big Four railroad will have been created.

Preliminary work, begun in September, 1915, consisted principally in getting adjacent land required for right of way cleared of houses and in preparing to build a few retaining walls at the west end to hold up the land and buildings or industries after the cut will have been made. The method of building retaining walls in a trench is expensive, but is the only way to avoid serious dangers to the manufacturing plants.

The improvement contemplates the elimination of 24 street crossings, of which two are arteries of the city crossing the tracks on curves. Thirteen bridges in all will be provided over the tracks, roughly one for every other street. In addition, there will be short streets parallel to the cut from streets with vacated crossings to adjacent streets with bridges. Five foot-bridges also will be built at points designated by the Director of Public Service.

The work has been undertaken at the request of the city, which, according to Ohio law, bears 35 per cent of the cost. Bonds for the portion of the cost to be paid by the city, were voted in the sum of $725,000 on Sept. 6, 1910. Plans for the project from its inception have been under the direction of A. J. Himes, engineer grade crossing elimination, of the N. Y. C. & St. L. R. R. Co., who had in charge the construction of grade crossing work for the railroad on the East Side of the city.

The work will be performed by direct labor. Previous experience has shown that many difficulties arising from the conflicting interests of contractors and railroad operating departments can be thus avoided, and with no sacrifice of economy in either time or money.

## SMALL STEAM SHOVEL WORK IN ROAD GRADING, CONTRA COSTA COUNTY, CALIFORNIA.

Contributed by J. E. Bonersmith, Engineer, Bates, Borland & Ayer, Oakland, Cal.

The work described was on the California State Highway between Tormey and Eckley in Contra Costa County, California, and was done in 1915. The road graded was four miles in length and contained 72,000 cu. yd. of excavation through a rather rough country. The material consisted of earth, soft and hard shale.

The method of work was as follows: After the culverts were constructed, two fresno gangs (each gang having a six-horse plow and from four to six fresnos) were started and made the fill over the culverts; also moved the dirt in all cuts where the hauls were 200 ft. and less. A Model 31 Marion Revolving Shovel followed the fresno gangs and loaded all the material that had to be hauled into dump wagons. The number of wagons varied from six to twelve. Behind the steam shovel, a small fresno with four muckers did all the finishing work.

The road was graded to a width of 21 ft. and through the thorough cuts the shovel had to turn through a full 180°. On this work, the average output of the shovel for an 8-hour day was 375 cu. yd., as there was considerable loss of time in spotting the wagons; but where the shovel was only going through 90°, it handled 510 cu. yd. The local water was the cause of some delay and since the water is a very serious question in the cost of equipment on any job, we now make it a rule to have the water analyzed and the proper boiler compound on hand before the shovel starts to work.

Costs to job in day rentals: Horses rented to job at $1.25 per working day; fresnos, wagons, etc., at $0.25 per working day; wagon and fresno drivers at $2.50 per day; Marion steam shovel, including fuel, runner, etc., $50 per day. These costs of equipment are used on all our work as we have found from many years of experience that it is the only way we can arrive at a true cost. Take the shovel as an example; its rental is based on the following charges:

| | |
|---|---|
| First cost, $8,200; life of shovel, 1,000 working days in six years; cost per day | $ 8.25 |
| 6 per cent interest on $8,200 for three years, $1,476; interest per day | 1.48 |
| Repairs (when the shovel is broken down the engineers', firemen, etc., time is charged to repairs), per day | 2.00 |
| Freight, knocking down, etc. (this cost was arrived at by cost kept on another shovel), per day | 3.00 |
| Fuel, ¾ ton of coal per working day at $12 per ton | 9.00 |
| Water wagon with four horses and driver, per day | 7.75 |
| Water and oil, per day | .85 |
| Engineer, per day | 6.75 |
| Fireman, per day | 3.00 |
| Two pit men at $2.50 per day | 5.00 |
| Incidentals | 2.92 |
| Total cost per day | $50.00 |

Following is the total cost of the above mentioned grading of the State Highway between Tormey and Eckley:

| | |
|---|---|
| Horses, 8,756 days at $1.25 per day | $10,945.00 |
| Equipment, 1,842 days at 25 ct. per day | 460.50 |
| Driver labor, 1,842 days at $2.50 per day | 4,605.00 |
| Steam shovel, 104 days at $50 per day | 5,200.00 |
| Foreman, 120 days at $5 per day | 600.00 |
| Timekeeper, 4 months at $75 per month | 300.00 |
| Muckers and slopers, 500 days at $2.25 per day | 1,125.00 |
| Muckers, slopers, etc., 212 days at $2.50 per day | 530.00 |
| Purchases (picks, shovels, lanterns, oils, etc.) | 182.60 |
| Insurance | 280.00 |
| Total cost | $24,248.10 |
| Cost per cu. yd | $00.3367 |

## DRAG LINE BACKFILLING MACHINE WORK IN HEAVY CLAY.

Contributed by Alvin C. Vogt, Norwood Park, Ill.

The illustration shows one of three backfilling machines working on sewer work in Norwood Park, Ill. The trenches are 24 in. to 36 in. wide in stiff clay and the backfilling is heavy work. The machine is operated by two men, is self-propelling, and has a 10-h.p. gasoline engine. The operating cost has been $10 per day and the average cut has been 600 ft. of 10 to 16-ft. trench per day. The backfiller is made by the F. C. Austin Drainage Excavator Co., Chicago, Ill.

Trench Backfiller Working in Heavy Clay.

## LAND DRAINAGE PROJECT IN FLORIDA.

The state of Florida offers an excellent field for the drainage contractor. At present more than 2,000,000 acres of land are either being drained or projects for their drainage are in contemplation. This is exclusive of the great Everglades reclamation development, which is probably the largest single undertaking of the kind in this country.

The cost of drainage in Florida for main and lateral varies ordinarily from $3 to $4 per acre as a minimum to a maximum of $7 to $8 per acre. The operations in general may be carried out by three different methods. The development may be as an individual or private enterprise, or a district may be organized. The district system, where large areas are affected, is usually employed.

There are two laws in the state providing for the organization of drainage districts. Under the older one jurisdiction over the district rests in the hands of the County Commissioners of the county in which the district is organized. The statute provides for the issuance of bonds for carrying out the work, but the paper of districts so organized is rarely considered favorably by bond houses, consequently contractors are frequently asked to accept the bonds or paper of such district in payment for work done. As these securities are not looked upon with favor by bond houses the question of their value to the contractor is an open one.

Under the new law, enacted by the legislature of 1913 and developed along the lines of the so-called Model Drainage Law, drafted by the National Drainage Congress, the administration of the district is in the hands of a board of three supervisors, elected by vote of the property holders in the district, such vote being cast on the basis of one vote to each acre of land owned. The district so created is under the jurisdiction of, and its supervisors answerable at all times to, the judge of the Circuit Court. Districts organized under this law can embrace lands in any number of counties.

The law provides for the issuing and sale of bonds. Certain features may and probably will be corrected in the law providing for these sales so that better prices may be obtained than under present conditions. Nevertheless, the bonds of these districts are at present marketable. All bond houses now buying in this field, however, demand a preliminary approval of the engineering features of the district in question by an engineer in whom the bond house has confidence. Under the existing conditions contractors doing work in a district organized under the law of 1913 can practically always expect to be paid in cash, the money ordinarily being in the hands of the Supervisors before construction work actually begins. Payments usually will be made monthly, with a certain per cent held out until final completion, according to prevailing practice.

For a general division, in drainage work in Florida, usually is in one of four classes of land: Muck, cypress swamps, pine woods, or open prairie. Work in muck usually can be handled best by floating dredge for main ditches and by ditching machines. Floating dredge equipment also can be used to advantage on the other types of land, though the greater mileage of ditches can usually be handled best by some type of a moving dipper machine. Small drag line outfits probably could be applied with advantage to a considerable portion of such work. As a general thing the percentage of rock encountered is comparatively small, while by far the greater portion of the ditching is through sand or marl.

The following is an outline of some of the drainage projects under way or in contemplation in Florida:

Baldwin Drainage District No. 1.—This includes three townships of land lying about Baldwin in Duval County. It has both prairie and muck lands within the boundaries. It is organized under the law of 1913. Surveys have been practically completed and plan of reclamation will be available shortly. Construction probably will be started within the next few months. Isham Randolph & Co., Jacksonville, Fla., are the chief engineers.

Lake Ashby Drainage District.—This district was organized under the law of 1913. It embraces 48,000 acres of land west of New Smyrna. Reports and surveys of engineers have been adopted. The estimated cost is $250,000. Isham Randolph & Co., Jacksonville, Fla., are the chief engineers.

Lake Worth Drainage District.—This was created under the law of 1913. It embraces approximately 125,000 acres near Lake Worth, and includes muck lands and prairie. Surveys have been made and plans prepared. Orrin Randolph, Lake Worth, Fla., is the chief engineer.

Peace Creek Drainage District.—The contract for the system for this 48,000-acre district was let early this month to the Elliott & Harman Engineering Co., Peoria, Ill., and Washington, D. C. The plan of reclamation calls for a 22-mile main canal through the center of the district and 120 miles of laterals. The estimated excavation is 2,432,743 cu. yd., and the estimated cost $258,877.

Upper St. Johns Drainage District.—This is stated to be the second largest district organized in the state at the present time. It includes approximately 265,000 acres of land along the valley of the Upper St. Johns River and extends from a point approximately west of Cocoa south to Fellsmere. The estimated cost of the improvement is in the neighborhood of $2,500,000. The surveys have been made by the engineers, Isham Randolph & Co., Jacksonville, Fla.

Homestead Sub-Drainage District.—This district was created under the laws of 1913, and is said to be the largest district organized in the state exclusive of the Everglades District. It includes approximately 277,000 acres of land, consisting of hummock, saw grass and marl prairie. Preliminary examinations of the tract have been made by the engineers, Isham Randolph & Co., and complete surveys will be started within the next few months.

Pinellas Park Drainage District.—Construction work is now under way on this district, which embraces about 13,000 acres of pine woods land. C. Dechant, Pinellas Park, is the engineer.

Lake Largo-Cross Bayou Drainage District.—Construction is well under way in this district. The district includes 13,000 acres of land immediately north of the Pinellas Park District.

Preliminary steps are being taken toward the creation under the 1913 law of a drainage district including that portion of Duval County between Trout Creek and the St. Johns River, exclusive of the Baldwin District No. 1, mentioned above. This district will be one of the largest in the state.

A drainage district of 5,210 acres has been organized near Hastings, Fla., under the law of 1913. Surveys have been made and plans prepared by the engineers, Ellis, Curtis & Kooker, Jacksonville, Fla. It is probable this district will be considerably enlarged.

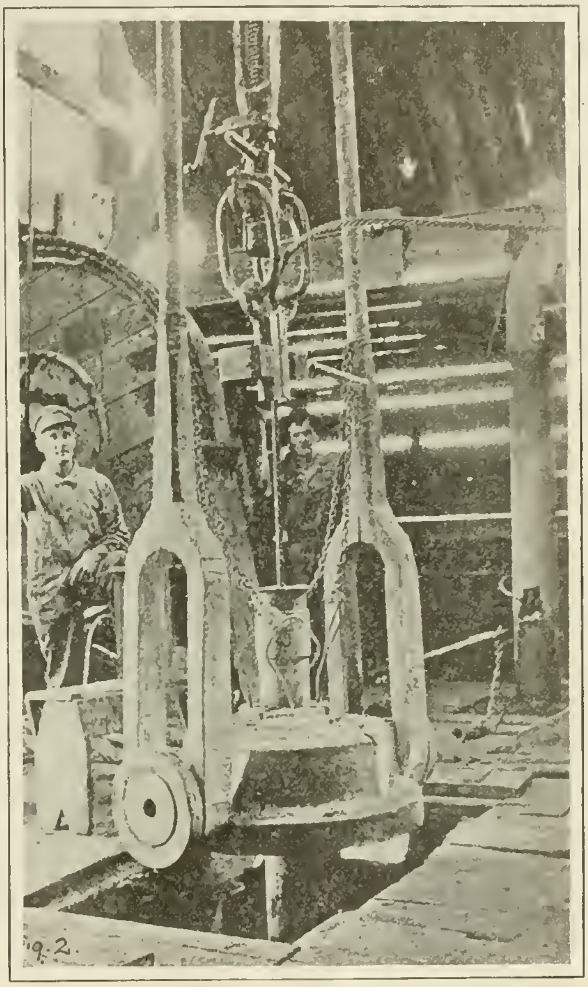
A number of good sized drainage developments are being carried out by private enterprise. The Southmere Farms Co. has construction under way on a 40,000-acre project west of Mims. The Titusville Fruit & Farm Land Co. has a 40,000 to 50,000-acre project near Indian River City. The greater portion of the area is muck land. A large amount of construction work has been completed. The Fellsmere Farms Co. contemplates an ultimate development covering approximately 118,000 acres. At the present time operations have been confined to a tract of approximately 50,000 acres, the drainage of which is practically completed. The Fort Pierce Farms Co. of Fort Pierce, has brought well along to completion the drainage of 25,000 to 30,000 acres of muck, prairie and pine land. The Indian Farms Co. at Vero, also has drained 30,000 acres to 35,000 acres of land and probably will double the development. The Everglades Sugar & Land Co., of Miami, contemplates starting construction at an early date on a tract of several thousand acres of Everglades land lying along the state drainage canal southwest of Fort Lauderdale.

We are indebted to George B. Hills, Jacksonville, Fla., engineer manager of the Isham Randolph & Co., Consulting Engineers, for the information given above.

## AN IMPROVED METHOD OF DEEP DRILLING LARGE DIAMETER WELLS.*

In drilling oil wells in the Coalinga oil field in California the problem is to reach a depth of 4,000 ft. or more with a string of pipe not less than 8½ in. in diameter and maintain the string free and movable. Some very promising results have recently been obtained by a method devised by Mr. William Kick. A large clearance for the pipe is obtained; the standard circulator system is used; the pipe is kept moving while drilling is in progress; each collar is "set up" twice before it goes below the bottom of the derrick cellar.

The large clearance is obtained by the use of a shoe of extra large diameter, from 1¼ to 1¾ in. larger than the collars on the pipe. Under-reaming is resorted to frequently and the hole is repeatedly under-reamed until the pipe is entirely free in passing a "shell" or hard streak.



Swinging Spider for Deep Well Drilling.

Spudding the pipe is avoided. When a conductor pipe is landed, the desirable extra clearance for the next string may be obtained by skipping one size of pipe, as for instance carrying a 10-in. string through a 15½-in., thus eliminating the 12½-in. size. This is necessary with the present sizes of pipe available, but a different design would save considerable expense in this matter.

This extra clearance is necessary in using the circulator system to allow free passage for the "returns." It obviates the danger of sand lodging between the strings of pipe and freezing the working string.

The well-known standard circulator system is used. Mud(clay)-laden fluid is forced down through the pipe under pressure by pumps (ordinary rotary slush pumps) and returned on the outside of the pipe, carrying the drillings with it. This fluid is run through a flume and into a pit, as in rotary work, and its consistency is regulated as with the rotary.

This mud-laden fluid presumably plasters up the walls of the hole, prevents sand and mud from running in and prevents caving. It is essential that circulation be interrupted as little as possible. Intermittent circulation seems to be worse than useless.

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*Extract from a paper by M. E. Lombardi in Transactions, American Institute of Mining Engineers.

The pipe is kept moving while drilling is in progress—i.e., without pulling out the tools—by means of a so-called swinging spider (see Fig. 1). The pipe is suspended by an ordinary spider provided with lugs to which are attached steel reins (sometimes chains or wire lines) which extend to a clevis above the walking beam, the beam operating between the reins. The clevis is attached to the casing block. The reins are about 40 ft. in length so that the pipe may be lowered to the bottom of a 30-ft. cellar. The cellar is made deep enough so that the stationary spider at the bottom is more than the length of one joint of pipe below the derrick floor. It follows that when a joint of pipe is added to the string the back-up tongs may be put on the second collar, which has been previously set up and which is now near the cellar bottom. The same result is obtained without back-up tongs, the pipe being held by the lower spider. Thus every joint is set up twice—once when it is put on and a second time after it has been subjected to the pull of the pipe below it and the vibration of drilling. This insures a tight joint.

It has been suggested that in territory where upper waters corrode iron and steel very fast, a 10-in. water string practically immune to this corrosion may be obtained as follows: Carry a 12½-in. string within a few feet of the point where water is to be shut off. This string may be as light and cheap as it is practical to carry, since the burden of sustaining the collapsing pressure of the water does not fall on it. Then land a 10-in. water string inside of this 12½-in. string at the proper point below it, and pump in enough cement to fill the space between the two strings.

This is mentioned simply as one of the advantages which may accrue from a drilling method by which a large-diameter string of pipe can be carried to depth with reasonable certainty.

Now as to the interesting item of cost. The bulk of the extra cost incurred is in movable tools and machinery, only the depreciation and upkeep on which are chargeable to the well drilled. Extra cost incidental to the drilling itself, other than above, consists in construction of the deep cellar, the installation of one extra boiler, the mud pumps and the extra fuel and water used, and one extra man. The swinging spider pumps, boiler, etc., are, of course, moved and used for successive wells. An idea of the extra cost items may be gained from the following:

| | | |
|---|---|---|
| Extra depth of cellar, drain, and circulator rigging | | $ 450.00 |
| Setting of extra boiler and circulator pump | | 250.00 |
| Mud flume, pits, etc. | | 100.00 |
| Total fixed costs per well | | $ 800.00 |
| Extra labor in drilling, per day | $ 7.00 | |
| Extra fuel, 77 bbl. of oil per day at 35 ct. | 2.45 | |
| Extra water, packing, etc., per day | 4.00 | |
| Total extra costs per day of 122 days | $13.45 | 1,640.90 |
| Depreciation at 18 per cent on $2,320, being value of outfit removed | | 136.00 |
| Total extra cost | | $2,576.90 |

In a typical well with the system under discussion 3,336 ft. of 10-in. pipe was set in 122 days. This is the value of only about 1,465 ft. of 12½-in. 45-lb. casing f. o. b. the field. No 12½-in. casing was used, so at least this amount was saved. Better average time is made with this method, so that at the most it is not more costly than the usual cable-tool drilling. As pointed out, its chief value lies in the fact that large-diameter pipe can be carried to depth with far more certainty.

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## COST OF EXCAVATING PAVEMENT, TRENCHING AND STEAM PIPE LAYING.

In the construction of a steam pipe line for a central heating system in Indianapolis, careful records of cost were kept. Assuming wages to be 25 ct. per hr., the following were the average unit costs of the direct labor, exclusive of foremanship and superintendence:

| | |
|---|---|
| | Per sq. yd. |
| Excavating concrete | $0.14 |
| Removing asphalt | 0.17 |
| Removing brick | 0.13 |
| Relaying concrete | 0.60 |
| Relaying brick | 0.40 |
| | Per cu. yd. |
| Excavating and wheeling | $0.62 |
| Backfilling | 0.83 |
| Loading wagons | 0.14 |
| | Per lin. ft. |
| Laying 12-in. steam pipe | $0.31 |
| Covering 12-in. steam pipe | 0.03 |
| Laying 18-in. tile | 0.09 |
| Placing trench sheeting | 0.20 |
| Pulling trench sheeting | 0.05 |

Setting plates and rollers cost 20 ct. per pair.

The costs varied rather widely from the averages above given, as indicated in the following table taken from "Electric World":

| | Units per man-hour. | | |
|---|---|---|---|
| | Maximum. | Minimum. | Average. |
| Removing asphalt, sq. yd. | 1.69 | 1.29 | 1.45 |
| Removing brick pavement, sq. yd. | 3.00 | 1.25 | 1.87 |
| Removing concrete (both hard and soft), sq. yd. | 3.36 | 0.57 | 1.79 |
| Excavating and wheeling, cu. yd. | 0.55 | 0.25 | 0.40 |
| Laying 12-in. pipe, foot | 1.25 | 0.33 | 0.8 |
| Setting plates and rollers, pair | 1.5 | 1.0 | 1.25 |
| Covering 12-in. pipe, foot | 15.5 | 5.3 | 7.6 |
| Laying 18-in. tile, foot | 5.25 | 0.55 | 2.9 |
| Backfilling, cu. yd. | 0.44 | 0.16 | 0.3 |
| Concreting, sq. yd. | 0.6 | 0.3 | 0.42 |
| Sheeting, foot | 1.5 | 1.0 | 1.25 |
| Pulling sheeting, foot | 6.12 | 4.45 | 5.0 |
| Laying brick, sq. yd. | 0.89 | 0.31 | 0.62 |
| Loading wagons, cu. yd. | 2.57 | 1.03 | 1.82 |

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## PUMPING WATER FOR IRRIGATION.

Contributed by Louis Schmeer, Irrigation Engineer, Colton, Cal.

(Continued from July 12, 1916.)

### Classification of Wells.

Wells may be classified as follows:

(1) Driven Wells: Wells constructed by driving strong screw-joint steel or wrought-iron pipes 1 to 4 in. in diameter into unconsolidated materials. If the pipe is not driven by the jetting method it carries at its lower end a strong drive point of steel, above this it is perforated for a distance of 10-20 ft. Driven wells are either constructed in batteries about a pumping station or else in rows on one or both sides of a suction pipe. Wells in batteries are usually supplied with air-lifts; air being supplied to all from a common receiver. In case the discharge is to be pumped to higher levels by more efficient apparatus it is necessary to get rid of the air arriving at the surface with the water. To accomplish this the lifts discharge into standpipes 10-12 ft. above the surface of the ground. From these the water flows to collecting pipes and pumps.

A battery of wells may be connected by simple syphon pipes with a large collecting well sunk to lower levels, thus permitting the pumping to be done by a single apparatus. Wells in rows are connected with suction collecting pipes leading to centrifugal or triplex pumps.

(2) Tubular bored or drilled wells. Wells from 4 to 36 in. in diameter sunk by various methods into unconsolidated strata or rock and in loose materials lined with screw-joint wrought iron or with riveted single or double steel casings.

(3) Common dug wells. Wells from 4-10 ft. in diameter and in loose materials lined with boards or masonry walls.

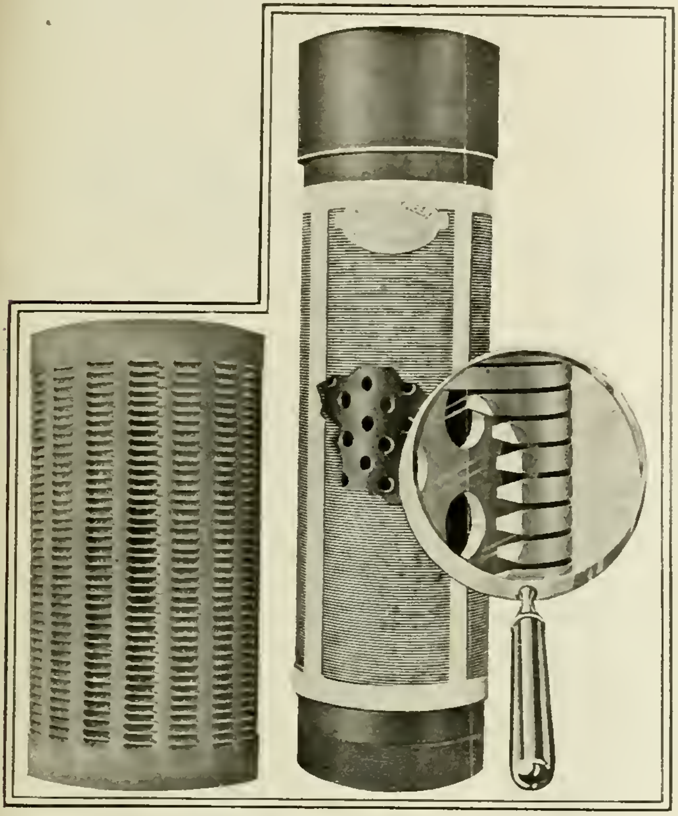
(4) Large dug or collection wells. Wells of moderate depth 10 to 100 ft. in diameter. In loose materials these wells are generally lined with masonry walls built on a foundation of rubble masonry, laid dry. Or, the lower part is lined with flanged, perforated plates of cast iron or steel, bolted together and a masonry wall is erected on the top flange. The yield of such wells is far from being proportional to their diameter; in water bearing sands it varies from 1.5 to 6 second ft. Their chief advantage lies in their freedom from clogging up, due to the slow entrance of the water, and in their great storage capacity. Their construction is indicated where waterbearing strata of low transmission capacity are found at depths not exceeding 40 ft. Collection wells in syphon connection with driven wells can, however, be sunk advantageously to greater depths.

(5) Artesian Wells. Tubular bored or drilled wells in which the water rises above the surface of the ground.

The name is, however, applied to all borings penetrating the deeper strata in which the water rises above the level of these strata. Artesian water in many cases simply means water originating in the deeper zones.

### Well Drilling Methods.

The outfit in use for drilling tubular wells in the Atlantic states and in Europe a century ago consisted of a square stationary derrick, a walking beam and connections operated by means of horsepower or a steam engine and some wheels and pulleys used in handling the tools. The tools consisted of iron rods 3-20 ft. long, screwed together and a drilling tool which was screwed either to the end of the lower rod or else it was of the free fall type, being dropped and picked up in the manner of the hammer of a piledriver. At a later period wooden poles, either with screw-jointed iron couplings or with some iron interlocking device displaced the iron rods. These in turn were subsequently displaced by the cable, now universally adopted. Pole tools however are still used in some parts of the country.



Layne Shutter Strainer and Wire Strainer for Wells.

The discovery of oil in Pennsylvania led to extensive drilling operations which resulted in the perfection and standardization of methods and tools. The various makes of rigs and tools now in use differ only in minor details.

For the drilling of irrigation wells a portable rig is mostly used; a permanent stationary derrick is, however, necessary if the well is to be equipped with a deep well double plunger pump.

Two types of portable rigs are in use, differing in the method by which a vertical up and down motion is imparted to the drilling tools. In each of these the energy of the prime mover is transmitted to a bandwheel and to a wristpin on the crank of this. The distance of the wristpin from the center of the shaft determines the length of the stroke imparted to the drilling tool. From the wristpin the energy is either transmitted to a walking beam by means of a pitman or else directly to the drilling cable by a mechanical device differing in the various makes of spudding rigs in use. The walking beam rig is the most complete, it will do for any kind of work from the lightest to the heaviest. By simply disconnecting the pitman from the wristpin of the bandwheel crank it may be converted into a spudding rig and this is usually done at the beginning of operations, before the distance between the bottom of the well and the walking beam is sufficient for the operation of a string of tools.

The spudding rig, having no walking beam, is best suited for light work and moderate depths of wells. It is used also in the hydraulic jetting process.

Connected with the walking beam of a complete rig is a so-called temper screw, 5-7 ft. long, carrying at its lower end the drilling cable held in a clamp. A slight turn of the screw increases or diminishes its length and thus serves to keep the drilling tools in touch with the material to be penetrated.

For operations in solid materials the string of tools proper consists of a rope socket, sinkers, jars, augur stem and drilling bit, all of which are screwed together in the order named, and a bailer. The rope socket, 2.5-4 ft. long receives the end of the cable. The sinkers, 6-16 ft. long add weight to the string when drilling a wet hole. The jars, 5-6 ft. long, consist of two interlocking links of strong steel bars and prove very useful, when drilling tools get stuck or lost. The downward stroke of the walking beam pushes the two links together, the upward stroke pulls them apart and at the end produces a jar of a force sufficient to disengage a stuck tool. The augur stem 1.5-48 ft. long, connects jars and drilling bit and further serves to add weight to the toolstring. Drilling bits are from 4-6 ft. long. The bailer consists of a steel tube usually 1.5 in. less in diameter than that of the casing or well. At its lower end it has a flap valve, opening inward. At the beginning of operations, when the hole has reached a depth of 6-10 ft. the tools are withdrawn and a piece of casing 6-10 ft. long is driven in, care being taken to keep it plumb. This first piece of casing carries at its lower end a slightly enlarged extra strong extension with a cutting edge, called the drive shoe. To the upper end of the casing another extension, called the drivehead is temporarily screwed on and on this the weight of the hammer driving the casing descends. In case the hole is dry, enough water is let in to convert the material loosened by the drill bit into a semi-liquid slush which readily enters the bailer lowered into it and is thus easily removed. The casing usually consists of steel tubing, cut to suitable lengths, with screw joints. When a solid formation is encountered, the casing is driven a few feet into it to form a watertight joint and then discontinued.

### The California Method.

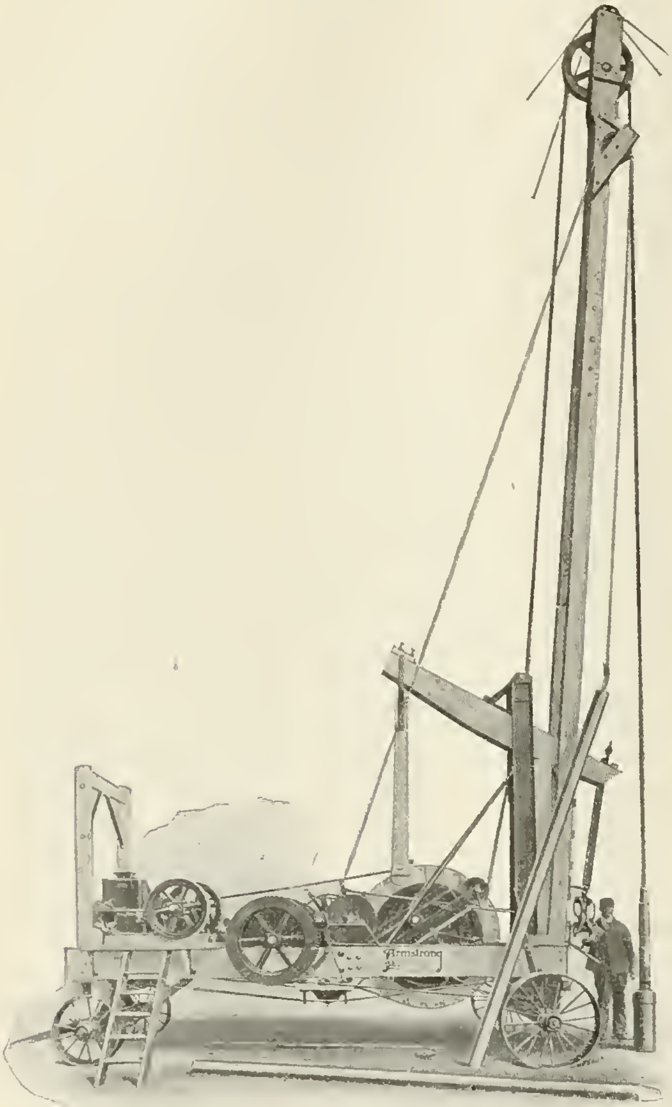
For operations in unconsolidated materials a method differing somewhat from the standard, described above, has been perfected. The rig used differs in so far from the standard, that the walking beam is placed much higher, or about 35 ft. from the ground. Solid drill bits are rarely used. The sand buckets or bailers are made extra strong and given sufficient weight to crush good sized stones, moderate layers of hardpan and even boulders to fragments small enough to enter the flap valve. For operations in such materials chisels of various shapes are riveted to an extra heavy drive shoe attached to the bailer. A 10-in. bailer, 20 ft. long, weighs from 1,500 to 2,000 pounds.

The casing consists of No. 12 to 16 gage lap riveted iron or steel tubes of two slightly differing diameters, cut in 2-ft. lengths. These are placed inside each other, stove pipe fashion, one piece overlapping the other 1 ft. The first casing rests on a starter, 8-10 ft. long. This consists in its upper part of two, in its lower part of three thicknesses of No. 12 casing, riveted together. To this is attached a heavy drive shoe of forged steel about 1 ft. long and provided with a cutting edge. The casings are driven (or pulled) by means of powerful hydraulic jacks, of about 50 tons capacity. These are bolted to heavy timbers and buried about the well at a depth of 8-10 ft. below the surface. Formerly the different pieces of casing were riveted together; at present the joints are simply center punched, an operation usually performed by the stroke of a pick. Stovepipe casing is watertight and will stand great pressures.

### The Hydraulic-Jetting Method.

The hydraulic-jetting outfit consists of a spudding rig and a force pump; the tools of a drill pipe and a drill bit with a nozzle. By means of the force pump, water under great pressure is driven through the drill pipe and drill bit and issues in a jet against the bottom of the hole. The drill pipe is operated by the spudding method. The particles of the material loosened by drill bit and jet are carried upward and out of the well by the ascending current and flow into a sump. The casing, steel pipe screwed together, is driven in the usual manner, by falling weights.

The hydraulic-jetting method is best suited for wells of small diameters, such as artesian borings. It is the quickest and cheapest method of sinking wells; its application is, however, limited to the penetration of formations consisting of fine grained materials.



Armstrong Walking Beam Well Drill.

### Perforated Casings and Strainers.

In order that the water present in the stratum may enter the well with the least hindrance it is desirable that perforations in casings and strainers should have an area surpassing the porosity percentage of the material; that is, if the porosity percentage of the material is equal to 30, the percentage of the perforated area of the casing or strainer should surpass 30.

Several methods of perforating casings in place have been tried, but none of them has given entirely satisfactory results. The chief difficulty lies in the fact, that the work, being performed far below the surface, can not be properly inspected.

The style of perforating tool most frequently used in punching stove pipe casings has a revolving cutter, punching 5 slits at each revolution of the wheel. With another style of tool vertical slits 3/8 in. wide and 6-12 in. long are punched into the casing. Experience has demonstrated that strainers inserted complete give better satisfaction and the present most approved practice is to put in such strainers and withdraw the casings. Those most frequently used are made of perforated brass, copper or galvanized steel plates, No. 8 gage. The perforations are punched in such a manner that no burrs appear on either side of the sheet. The area of perforations is from 40 to 50 per cent. The made up tube is wound with brass or copper wire of a suitable size and so spaced as to prevent the entrance of the minor sizes of soil grains present in the material. The wire wound strainers are, however, not free from objections; the voids between the wires become occasionally completely clogged and the efficiency destroyed.

There are several patented strainers on the market presenting entirely smooth surfaces to the material in contact. This to a great extent prevents the clogging of the strainer.

In the Layne strainer the brass or copper wire wound around the tube is not circular but wedge-shaped, the wedge pointing inward and presenting a flat smooth surface towards the outside. The wire used is all of the same dimensions, but spaced differently, leaving openings from 0.001 in. in width to any other width desired. The Cook strainer consists of a brass tube with horizontal wedge-shaped openings.

In the Layne shutter strainer, which is made of boiler iron and intended for wells of large diameters, the perforations are similar in shape to the openings in a window shutter. Through these openings nothing can enter horizontally and only the water, being much lighter than the sand, ascends and enters.

Usually the diameter of the strainer inserted is 1.5-2 in. less than that of the casing. Where there is a joint to be made between a casing and a strainer, it is made watertight by the insertion of an annular strip of lead, forming a seal. When the casing is withdrawn, starter and drive shoe are left in the ground.

### The Cleaning Out of Wells.

The material composing a waterbearing stratum consists of a mixture of grains of various sizes. It is obvious that the elimination of the finer soil grains occupying the pores between the larger ones will greatly facilitate the movement of water in the material. This is especially true of the region in the immediate vicinity of the well, where the water arrives from all directions. During recent years a method has been found by which the finer soil grains present in the material surrounding the well may be to a great extent washed out and the flow thereby considerably increased, frequently 50 per cent and over. The apparatus used in the work is the common Pohle air lift pump. Since this is an apparatus of low efficiency its installation is only temporary and consists of a makeshift combination of an air compressor, an air receiver, a discharge pipe 2 in. less in diameter than that of the casing and an air pipe having a diameter equal to one-fourth of that of the discharge pipe. For the work in hand it is not necessary to pay any attention to the proper amount of submergence. When operations begin, the well as well as the discharge pipe of the pump, are closed air tight. Air is then turned on under a light pressure, about 10 to 15 pounds per square inch. The pressure is gradually increased until it reaches about 40 to 50 pounds per square inch in both receiver and well. These high pressures force water and air through the perforations of the strainer far out into the waterbearing stratum. When the discharge valve is opened the resulting shock drives the finer materials, clay, silt and fine sand grains into the well, from whence they are ejected through the discharge pipe. The operation is repeated as long as the discharge carries materials held in suspension.

When wells are cleaned out in this fashion it is evident that wire wound strainers or others with fine slits or perforations are not to be used. Strainers made of galvanized iron or of brass, No. 8 gage, smooth on both sides, with perforations 3/16 to ¼ in. wide and 1 to 2 in. long, have given good service. The area of the perforations should be between 35 and 40 per cent.

## The Cost of Drilling and Casing Tubular Wells.

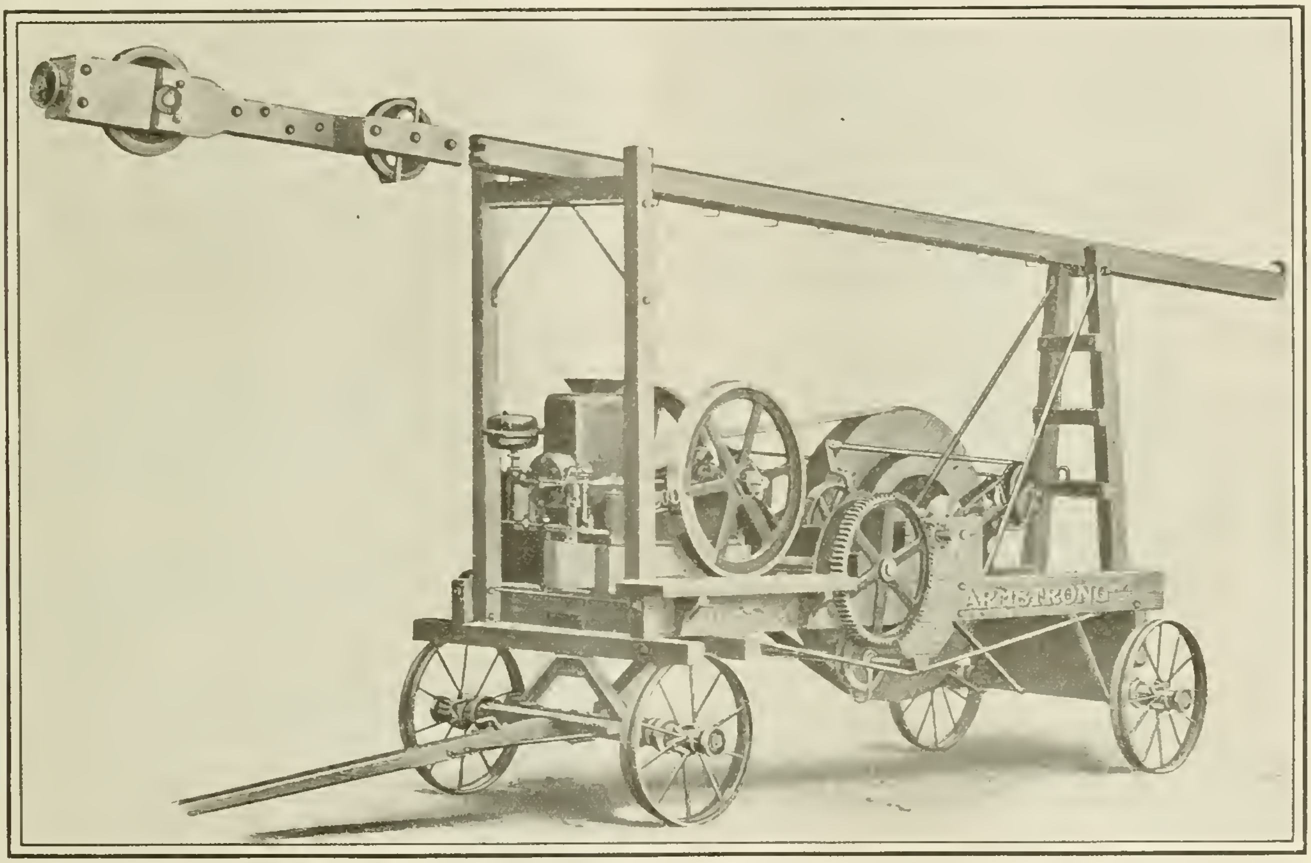
The cost of sinking wells differs with the material to be penetrated and with the method which can be used. By the jetting method wells from 4 to 8 in. in diameter can be sunk in fine material for 25-40 ct. per foot, including the driving of the casing.

The cost of sinking wells in unconsolidated materials by the California method, including the driving of the double casing, is about as follows:

TABLE VI.

Cost in cents per foot.

| Depth. | Diameter of well in inches. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| First 100 ft. | 30 | 30 | 35 | 40 | 50 | 60 | 65 | 75 | 80 | 90 | 100 | 110 | 120 | 130 |
| For each 50 ft. additional in clay, loam or sand add, cents per foot | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 10 | 10 | 10 | 10 | 10 | 10 |
| For each 50 ft. additional in gravel or gravel with boulders add, cents per foot | 25 | 25 | 25 | 30 | 30 | 30 | 35 | 35 | 35 | 40 | 40 | 40 | 45 | 45 |



Armstrong Spudding Well Drill.

To the cost of sinking the well must be added the cost of the casing which fluctuates with the price of steel. The present price of casings strong enough to sustain an internal pressure of 100 lb. per square inch is about as follows:

TABLE VII.

| Diameter in Inches. | Lap riveted casing at 8 ct. per lb. Gage. | | | Welded steel pipe with screw joints. Factory prices plus 25 per cent. | |
|---|---|---|---|---|---|
| | 16 | 14 | 12 | Black. | Galvanized. |
| 4 | 30 | .. | .. | 44 | 70* |
| 5 | 36 | 46 | .. | 59 | 95 |
| 6 | 42 | 52 | .. | 28 | 124 |
| 7 | 48 | 60 | .. | 104 | 160 |
| 8 | 56 | 70 | 96 | 109 | 169 |
| 9 | 60 | 74 | 102 | 151 | 231 |
| 10 | 66 | 82 | 114 | 180 | 271 |
| 11 | 72 | 88 | 122 | 203 | 310 |
| 12 | 80 | 100 | 136 | 223 | 340 |
| 13 | 84 | 104 | 144 | ... | ... |
| 14 | 90 | 112 | 158 | ... | ... |
| 15 | 94 | 116 | 164 | ... | ... |
| 16 | .. | 128 | 178 | ... | ... |
| 18 | .. | 148 | 202 | ... | ... |
| 20 | .. | 168 | 220 | ... | ... |
| 22 | .. | 176 | 240 | ... | ... |
| 24 | .. | ... | 256 | ... | ... |

*Corrected for latest prices.

A single thickness of steel casing will safely stand an earth pressure of

$$H = \frac{t}{\text{diameter in inches}} \text{ feet;}$$

in which t = 2,700 for 16 gage, 3,600 for 14 gage, and 4,500 for 12 gage steel.

The present prices of Layne well screens or strainers are as follows:

TABLE VIII.

Wire Wound Screen of Perforated Steel.

| Diam. in inches. | Per ft. | Diam. in inches. | Per ft. |
|---|---|---|---|
| 3½ | $5.60 | 8⅝ | $ 8.40 |
| 4 | 5.80 | 9⅝ | 9.20 |
| 4½ | 6.04 | 10⅝ | 11.20 |
| 5 | 6.14 | 11⅝ | 11.50 |
| 5⅝ | 6.24 | 12½ | 12.90 |
| 6¼ | 6.40 | 13½ | 16.00 |
| 6⅝ | 6.80 | 14½ | 20.20 |
| 7⅝ | 9.10 | 15½ | 24.00 |
| 8¼ | 7.80 | | |

Shutter Screen of Boiler Steel.

| Diam. in inches. | Per ft. | Diam. in inches. | Per ft. |
|---|---|---|---|
| 11 | $7.67 | 24 | $10.67 |
| 13 | 8.00 | 26 | 12.67 |
| 15 | 8.33 | 28 | 15.00 |
| 17 | 8.67 | 30 | 17.67 |
| 21 | 9.33 | | |

## The Cost of Well Pits.

The dimensions of well pits for horizontal pumps direct connected to electric motors or belted to engines are 6 by 12 to 14 by 14 ft. and those for vertical pumps 8 by 8 ft. or less. For a depth of 25 ft. the cost of excavation is about as follows:

| Material. | Cost per cu. yd. in dollars. |
|---|---|
| Sand, earth and loose gravel | 0.75-0.85 |
| Light clay | 0.90-1.00 |
| Dry clay | 1.15-1.25 |
| Wet clay, hard pan | 1.45-1.55 |

For each additional foot of depth one per cent may be added, so that for a depth of 125 ft. the cost will be doubled.

A lining consisting of 2-in. planks or 4-in. concrete costs about 16, one of 6-in. concrete, 24 ct. per square foot of surface. The cost of a 12 by 12 ft. pit, 25 ft. deep and lined with 2-in. planks or 4-in. concrete is consequently about as follows:

| | |
|---|---|
| Excavation $= \frac{12 \times 12 \times 25 \times 0.95}{27} =$ | $100.00 |
| Lining $= 4 \times 12 \times 25 \times 0.16 =$ | 192.00 |
| Concrete floor $= 12 \times 12 \times 0.16$ | 23.04 |
| Total | $315.04 |

The deeper pits are given a circular section 8-12 ft. in diameter and the thickness of the masonry or plain concrete wall is computed from the formula:

$$T = \frac{H\,d\,R}{32\,s}\,\text{Tang.}^2\left(45^\circ - \frac{\phi}{2}\right)$$

in which $T$ = thickness of lining in feet;

$H$ = depth of well;

$R$ = radius of well;

$d$ = density of material, assumed to be equal to 2;

$S$ = safe crushing strength of plain concrete in tons per square foot, assumed to be equal to 15;

$\text{tang.}^2\left(45^\circ - \frac{\phi}{2}\right)$ = factor denoting the influence of the angle of repose of the material surrounding the wall upon the horizontal pressure; for sand, gravel, detritus, dry loam or clay equal to 0.5354.

For a pit or well 100 ft. deep and 10 ft. in diameter this gives, inserting values

$$T = \frac{100 \times 2 \times 5}{32 \times 15}\ 0.5354 = 1.11 \text{ ft.}$$

The method in use in sinking these masonry lined circular pits is similar to the one used in sinking bridge piers. An excavation is sunk to a depth of 6-10 ft. and a concrete lining put in, which is given a thickness corresponding to the depth to which the pit is to be finally sunk. When the concrete has gained sufficient strength to resist the soil pressures forms are removed and excavation resumed and extended under the masonry. As the concrete ring sinks under its own weight additional sections are built on top of it until the desired depth is attained.

(To be continued.)

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## DITCHING AND DIGGING POLE HOLES WITH DYNAMITE.

Contributed by Thomas M. Knight, E. I. Du Pont de Nemours & Co., Wilmington, Del.

There are hundreds of thousands of miles of ditches needed in this country. Excess water must be carried away, and in the arid regions water must be brought to the land. Ditches both small and large, deep and shallow, to fill the particular needs are required. How to dig these ditches at the least cost in the quickest time possible is a question of vital interest to the engineer.

In times past, pick and shovel, mechanical diggers, heavy ditching machinery and floating dredges all played their part in the excavation of ditches. In recent years dynamite has been added to this list. All of these methods have their place; yet for a great many classes of ditches the use of dynamite is cheapest and most satisfactory. However, in cases of ditches of from one to several miles in length and 6 ft. deep or over other means than by the use of dynamite will probably be found more economical, but for ditches from 3 ft. wide to 2 ft. deep up to 16 ft. wide and 6 ft. deep the use of dynamite will be found to be a very economical way of digging. The study of all conditions is advised and the use of the cheapest method is recommended in every case. Ditches may be dug with dynamite in the softest swamp lands or through the hardest rock. In fact, dynamite will do the work in any soil, with the exception of loose, dry sand.

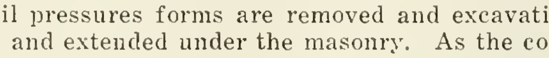


Fig. 1—Plan of Wire Connections for Blasting a Narrow Ditch Through Dry Ground.

In ditching with dynamite no expensive machinery is required, and the cost and labor of transporting this machinery is eliminated. The equipment required is generally a sledge and punch bar or soil auger, and very often two men can carry all the supplies that are needed for a few hundred feet of ditch. Dynamite works exceptionally well in rough and swampy lands, and will dig a clean-cut channel through places so wild that teams or machinery could not be brought to work in them. A little shoveling is sometimes required, and, as the blast scatters the soil over an area approximately 150 ft. on each side of the ditch, there are no spoil banks with which to contend in aftertimes. It is as easy to dig a curved ditch as a straight one, as the center of the ditch is where the dynamite cartridges are placed.

In wet weather it is often imperative that a ditch be dug very quickly to avert the flooding of certain sections, and the use of dynamite in cases like this is the means of saving an untold number of dollars.

There are two methods of blasting ditches, propagated and electric. The propagated method can be carried on only in wet soils, while the electric one may be practiced in both wet and dry soils. The grades of explosives used, blasting supplies needed, and methods of loading vary with the two methods.

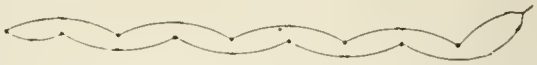


Fig. 2. A Second Method of Wiring One Line of Holes.

In wet or swampy soils the ditching can best be done by the propagated method. In firing a propagated blast the cartridges are placed from 18 to 24 in. apart and at the proper determined depth. A blasting cap and fuse is inserted in the center cartridge and fired. The force of the explosion of this cartridge fires or detonates the balance of the cartridges so placed. If the ditch is to be a wide one, then a parallel row of cartridges, and sometimes a third row, is required. In such a case there should be a cartridge or two put down extra to connect the parallel rows to make sure of the simultaneous detonation of all the charges. It is also a good practice to charge the two cartridges on either side of the primer with a blasting cap to further insure perfect detonation. In a propagated blast a straight nitroglycerine dynamite must be used, as other grades are too insensitive to be fired in this manner. This method of blasting should be carried on only in a fairly warm soil. It should not be attempted in icy water or in cold weather.

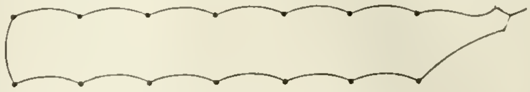


Fig. 3—Plan Showing Methods of Connecting Wires for Blasting a Large Ditch Through Dry Ground.

If stumps, boulders, or other obstructions are directly in the line of the ditch it is best to prime a cartridge on either side of the obstruction and fire these with an electric blasting machine. The explosive wave might carry through or around these, but it does not pay to take the risk. When such obstructions are to be removed from the ditch extra charges are needed to be placed under them.

The electric method of blasting ditches may be carried on regardless of soil conditions and temperature. It has the advantage over the propagated method in so much that the low freezing and less sensitive grades of dynamite may be used and larger charges may be employed in the bore or loading hole, and these placed correspondingly farther apart, thus reducing the loading cost. The method of procedure is exactly the same as with the propagated blast, except every charge must be primed with an electric blasting cap and the wires connected up. To fire this an electric blasting machine is used. Where more than one cartridge is used in a hole, the one containing the primer should be placed on top and the cap pointed downward. Blasting machines have various actual capacities; so don't overload them. If one is rated at fifty, it is far better to fire forty-five charges than to try to fire fifty-five. Be on the safe side. Where the water does not rise 2 ft. in the hole, it should be filled with suitable tamping material and packed tightly.

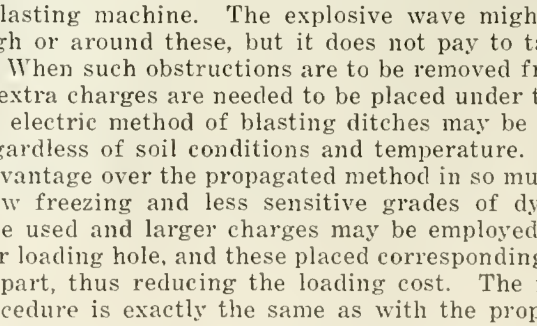


Fig. 4—Method of Connecting Wires for a Ditch Blast Where Three Lines of Holes Are Used.

If one set of holes is to be fired they can best be connected as shown in Fig. 1. Figure 2 also shows a method of connecting one line of holes. For two sets of holes the connections are made as in Fig. 3. If a ditch is of a sufficient width to demand three lines of holes, the method of connecting the wires is shown in Fig. 4. Figure 5 gives a view of the longitudinal section of the placing of charges and wiring for an electric ditch blast.

The amount of dynamite needed, the space between the charges, and the depth to which they are placed to dig a ditch of the required size vary greatly. No set rule can be laid down. Roughly speaking, in average soils a pound of 50 per cent straight nitroglycerine dynamite should dig a running yard of ditch 6 ft. wide and from 2½ to 3 ft. deep. That would mean the placing of a cartridge of dynamite every 18 in. at a depth of about 30 in.

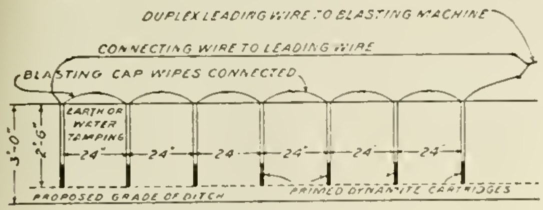

DUPLEX LEADING WIRE TO BLASTING MACHINE
CONNECTING WIRE TO LEADING WIRE
BLASTING CAP WIRES CONNECTED
EARTH OR WATER TAMPING
3'-0"
2'-6"
24"
24"
24
24"
24"
24"
PROPOSED GRADE OF DITCH
PRIMED DYNAMITE CARTRIDGES

Fig. 5—Longitudinal Section Showing Method of Loading With Electric Blasting Caps for Blasting a Ditch.

The only sure way to proceed either in a propagated or electric blast is to first fire trial or test shots. For ditches from 3 to 3½ ft. deep the depth of the bore or loading holes should be from 2 to 2½ ft. and the spacings from 20 to 24 in. apart. It is well to load about ten holes as a trial and note the results. If a clean ditch has been blown to the required width and depth, the work may proceed, but if too deep or too shallow, vary the spacing, depth, and charges accordingly. Two or three test shots in most cases will determine the correct loading. In some cases where a shallow ditch is required and the soil is soft and wet half a cartridge will be sufficient to do the work. When the dynamite moves too much ground in propagated blasts and the spacing between the charges is twenty-four inches, cut down the size of the charge rather than increase the spacings, as 24 in. is usually the limit of successful propagated blasts.

The bore or loading holes can be put down in swampy and wet land with a wooden stick or bar with little trouble, while in harder soils a hole may be put down with a bar and sledge or crowbar.

Soil conditions vary in every location; so it is impossible to arrive at any cost prices until test shots have been made. The accompanying Table I gives the approximate amount of 50 per cent straight nitroglycerine dynamite required to dig ditches of various width. Table II shows the amount of dynamite required for a given length of ditch.

Fig. 6—Dynamite Charges Tied to a Stick and Ready to Load for a Post Hole Blast.

Dynamite is also employed to good advantage in the digging of post and pole holes. It not only saves time and labor, but it reduces the number of laborers required as well.

In digging pole holes with dynamite the dirt is packed solidly around the sides of the hole, which is greatly to be desired. The tendency in hand digging in hard soils or shale is to make the holes shallow. This danger is wholly eliminated where explosives are employed.

In preparing to blast out a hole with dynamite, a hole is first dug with a spade about 6 or 8 in. deep to the full diameter of the hole required. This is to relieve the pressure on the blasted hole and to prevent excessive shattering.

A bore or loading hole is then put down in the center of the shallow hole to within about 6 in. of the depth required. A soil auger or churn drill will probably work the best in putting down this hole.

The dynamite used in blowing out the hole must be divided into several charges and spaced so that when placed in the hole the top charge will be about 20 in. below the surface. The charges, consisting of a cartridge or fraction of one, may be tied to a lath or any other light stick (see Fig. 6) at distances from 6 to 24 in. apart. The spacings and charges are determined by the character of the soil and depth and diameter of the hole required. Here, again, test shots must be made to determine the most satisfactory and economical method of procedure.

TABLE I.—APPROXIMATE TABLE OF CHARGES OF STRAIGHT 50% DYNAMITE FOR BLASTING DITCH WITHOUT A BLASTING MACHINE.

| Top width of ditch. | Approximate number of cartridges per hole required for ditches of various depths. 2½ to 3 ft. | 4 ft. | 5 ft. | 6 ft. | Number of parallel rows required. | Distance between rows in Inches. |
|---|---|---|---|---|---|---|
| 6 | 1 | 2 | 3 | 5 | 1 | .. |
| 8 | 1 | 2 | 3 | 5 | 1 or 2 | 30 |
| 10 | 1 | 2 | 3 | 5 | 2 | 36 |
| 12 | 1 | 2 | 3 | 5 | 2 | 42 |
| 14 | 1 | 2 | 3 | 5 | 2 | 48 |
| 16 | 1 | 2 | 3 | 5 | 3 | 36 |
| 18 | 1 | 2 | 3 | 5 | 3 | 42 |

The top cartridge or piece of cartridge is primed with a fuse and blasting cap or an electric blasting cap. (Nothing smaller than a No. 6 should be used, so as to insure perfect detonation.) The lath with the primer on top and charges attached is then placed in the hole (see Fig. 7). If water is in the hole of sufficient depth to cover the charges, including the primer, no tamping is necessary. If, on the other hand, the hole is dry, better results may be secured if the hole is tamped at the top about the charge. In tamping the hole care should be taken to see that no dirt or pieces of sod get between the primer and charges below. In firing, the force of the explosion of the primer

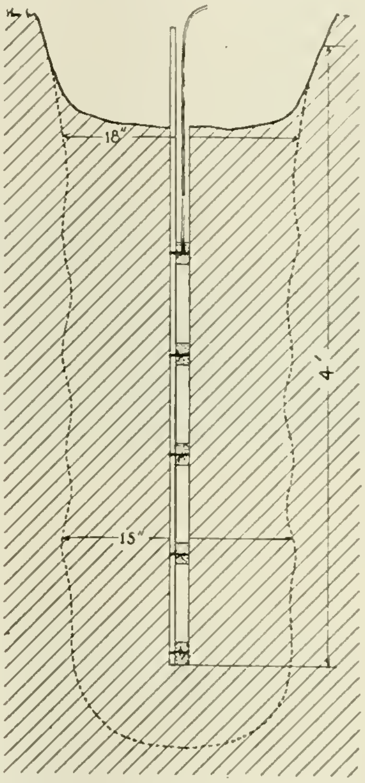


Fig. 7—Method of Loading for Pole Hole Blasting.

TABLE II.

| Spacing between holes in row, in. | 10 rods: Number of holes. | 10 rods: Dynamite required using charges per hole of Half cartridge, lb. | 10 rods: Whole cartridge, lb. | ¼ mile: Number of holes. | ¼ mile: Dynamite required using charges per hole of Half cartridge, lb. | ¼ mile: Whole cartridge, lb. | ½ mile: Number of holes. | ½ mile: Dynamite required using charges per hole of Half cartridge, lb. | ½ mile: Whole cartridge, lb. |
|---|---|---|---|---|---|---|---|---|---|
| 18 | 110 | 28 | 55 | 880 | 220 | 440 | 1,760 | 440 | 880 |
| 20 | 99 | 25 | 49 | 792 | 198 | 396 | 1,584 | 396 | 792 |
| 24 | 83 | 21 | 41 | 664 | 166 | 332 | 1,328 | 332 | 664 |
| 26 | 76 | 19 | 38 | 608 | 152 | 304 | 1,216 | 304 | 608 |
| 28 | 71 | 18 | 36 | 566 | 142 | 284 | 1,132 | 283 | 566 |

1 rod—16½ feet.
10 rods—165 feet or 55 yards.
¼ mile—1,320 feet or 440 yards or 80 rods.
½ mile—2,640 feet or 880 yards or 160 rods.

explodes the other charges, but if dirt or sod intervenes the charges below will fail to explode. Water transmits the detonation, but dry dirt retards or cuts it off entirely.

In a test shot following the described method in a tight clay soil, an excellent, clean-cut, open hole was blown out four and a half feet deep. One-third of a cartridge or straight 60 per cent dynamite was placed in the bottom of the hole; one-third of a cartridge of the same strength eight inches from the bottom, and one-half cartridge of 40 per cent low freezing extra dynamite was placed 20 in. below the top. There was no tamping in this case. Very little hand work was required to clean the hole out.

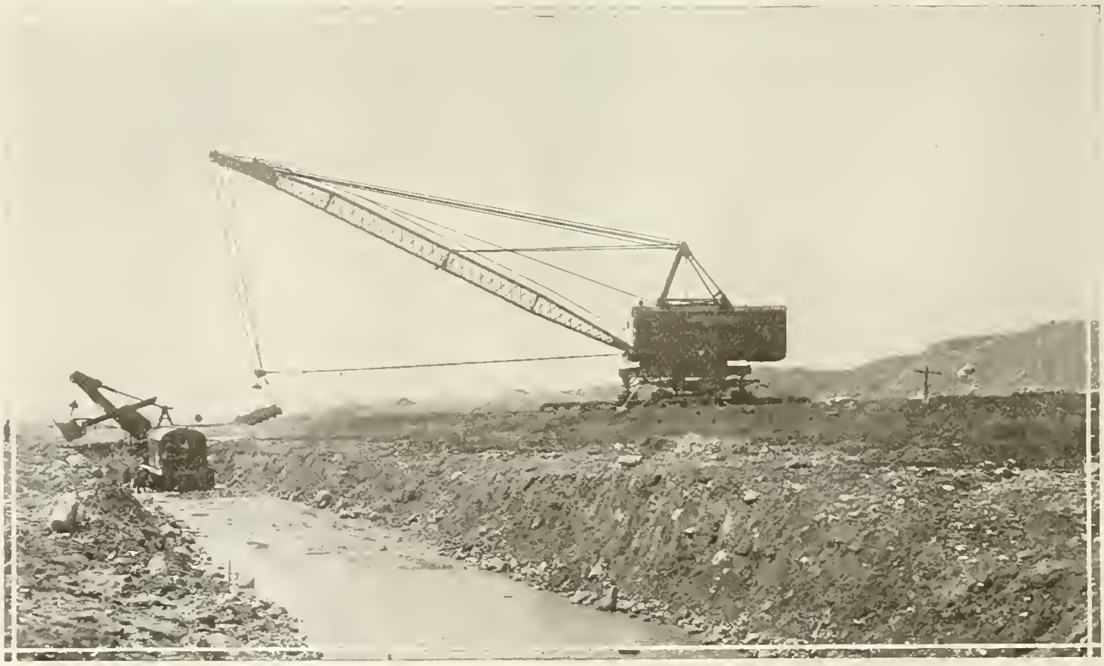
Another test shot was recently made in a wet blue clay soil. A bore hole was put down 6 ft. deep. Seven charges, each containing one-third of a cartridge of 50 per cent straight nitroglycerine dynamite, were placed 6 in. apart, beginning at the bottom. This blew out a uniform, clean-cut hole, 78 in. deep, which required less than three minutes of hand work to clean out. The walls were compact and hard. The shot was satisfactory in every way.

In pole hole blasting the straight dynamites give good results in warm weather, while the extras and low freezing grades give satisfactory results both in warm and cold weather. The straight dynamites are more sensitive and quicker in their action than the others.

Dynamite saves time and money, and its use is conducive to speed and economy.

## DRAG-LINE EXCAVATOR FOR HANDLING SPOIL FROM STEAM SHOVEL TO SPOIL BANK.

The illustration shows a drag-line excavator put to novel use in constructing Section 11 of the Calumet-Sag Branch of the Chicago Drainage Canal. This section of the branch canal is 5,200 ft. long, 39 ft. deep, and 192 ft. wide at the top; the bottom width is 36 ft. for part of its length and 50 ft. for the remainder of its length. In selecting plant for this work the facts to be taken into consideration were that there was a considerable quantity of stripping and glacial drift to be removed first and that beneath this was hard glacial drift requiring a powerful excavator. For the top excavation a drag-line excavator was suitable, but it could not handle economically the hard glacial drift. The scheme worked out was to use for the top excavation a 235-ton Bucyrus drag-line with a $3\frac{1}{2}$ cu. yd. bucket and a working radius of $128\frac{1}{2}$ ft., and for the glacial drift to use a 70-ton Bucyrus shovel. To handle the spoil from the shovel it was the idea to transform the drag-line excavator into a derrick, replacing the excavator bucket by a steel skip 9 ft. x 9 ft. 7 in. x $2\frac{1}{2}$ ft. The plant as thus transformed is shown by the illustration. In planning this arrangement it was considered that while a tipple might handle the spoil somewhat faster it would involve additional investment unnecessary if the drag-line transformed into a derrick could be substituted. Also when the work was done the drag-line would have far greater market value than would a tipple designed for a specific job. The work of the drag-line as a derrick has been successful. The contractor for the work is James O. Heyworth, Chicago, Ill.



Drag-Line Excavator Handling Spoil from a Steam Shovel, Calumet-Sag Canal.

## USING THE PANTOGRAPH FOR ODD SCALES.

Contributed by T. H. Mycum, Dayton, Ohio.

In the average drafting room, an ordinary, cheap pantograph is of no value in reducing or enlarging drawings accurately to scale. However, for obtaining copies for reference or for record purposes not demanding a very accurate scale, a pantograph is invaluable as a time saver. Often a reproduction is wanted for survey or preliminary investigation sooner than a satisfactory copy could be made by hand. Especially in the case of maps, or similar drawings a copy hand-made to different scale is expensive and unsatisfactory; while with a cheap pantograph, better work can be turned out and in much less time, providing the pantograph can be arranged to enlarge in the ratio of the scales of the original and the copy.

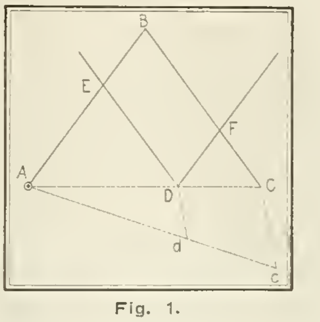


Fig. 1.

If the only original available is a printed copy, reduced to no definite scale, or if the ratio of scales is odd, the ordinary pantograph cannot be used to obtain an enlargement to scale without locating and boring new holes.

The method of determining the locations of holes for any ratios whatever is not at once apparent, the first time the proposition is met. Consider the ordinary pantograph mechanism (Fig. 1). In any position, links AB and DF, and DE and BC are always parallel; and points A, D and C always lie in the same straight line. The points D and C can move only in the one (or both) of two ways: in radial lines through A, or in arcs of circles concentric about A. Since in either manner their movements are always parallel, in any random movement also—which is a combination of both radial and circular—their movements will be parallel at any instant.

If then, Cc is enlarged from Dd, they are parallel, and the ratio of enlargement is Cc:Dd. Then, from similar triangles, AC:AD::Cc:Dd. Also triangles ABC, AED, and DFC are all similar, having their respective sides parallel. Therefore—

Cc:Dd :: AC:AD :: BC:DE :: DE:FC :: BC:BF :: BF:FC, etc.

Thus, if the ratio of scales, Cc:Dd, is R and BC is 1, the length of the link is $R = \frac{1}{DE} = \frac{1}{BF}$ and $DE = BF = \frac{1}{R}$

As usually made, all the links are alike. Therefore, all the triangles are isosceles, and FD = FC. That is, FD = BE = 1-BF.

Thus, the required distance to bore new holes for any ratio of enlargement, is always equal to the length of link divided by the ratio.

Suppose, for example, the scale of some map reduced for publication is found from certain distances given on the print to be 1 in. = 237 ft. It is desired to enlarge and copy this print to a scale 1 in. = 200 ft. The ratio of enlargement, R, is 237 ÷ 200 = 1.185. The length of the link, l, is 20 in., perhaps. Then the distance of the hole from the end, for two links, is

$$x = 20 \div 1.185 = 16.88 \text{ in.}$$

and for the other two links it is 20 in. — 16.88 in. = 3.12 in. The approximate location can be determined for each link by inspection, by noting the ratios for the holes already provided, and the proper distance to use at once determined.

## A NEW SELF-PROPELLING DRAG LINE EXCAVATOR.

A drag line excavator self-propelling, either on broad faced traction wheels or on "Corduroy Grips," is illustrated by the accompanying engravings. As shown by Fig. 1 this excavator has a revolving frame supporting a boom and internal combustion engine, an A-frame, a drag drum, a hoisting drum, a boom topping lift drum, a tubular water cooling radiator, an air compressor, a centrifugal water circulating pump, a gasoline tank suspended from beneath and a compressed air tank also suspended from beneath.

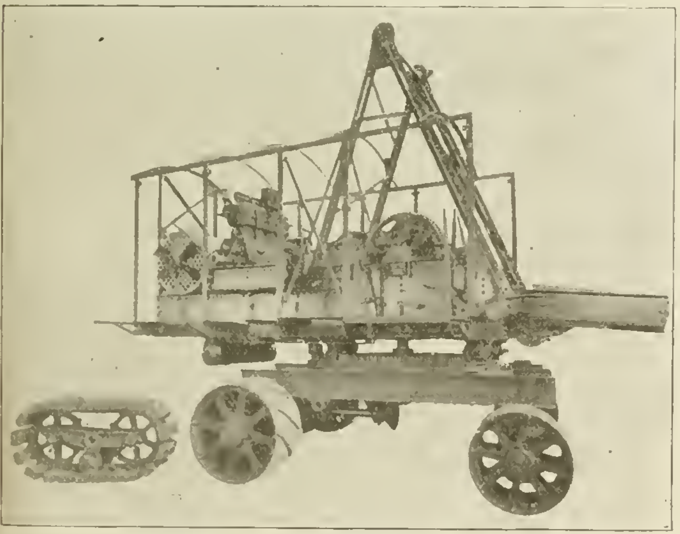


Fig. 1—View Showing Framing and Machinery of Self-Propelling Drag Line Excavator.

All machinery, including boom and A-frame, is sustained on two heavy girders. This upper frame rotates on the lower frame by rack and pinion and revolves on four two-wheeled trucks, treading upon a 60-lb. rail circle. Truck frame wheels and center castings are made of annealed steel. The lower frame is of I-beam construction, designed for taking all the heavy strains that are imposed upon it.

The engine house consists of angle iron framing encased in double beamed and matched yellow pine ceiling. The roof is of the same material and is covered with heavy canvas. The whole is thoroughly painted. Water circulation and force feed lubrication are entirely automatic. The main structural dimensions and other details are:

Length of boom, 40 ft.; capacity of bucket, 1 cu. yd.; horsepower of engine, 70; rotating speed, 2½ revolutions per minute; diameter of turntable, 8 ft.; character of material in traction wheels, cast steel; wheels provided with three sets of spokes.

The corduroy grips are driven from live axle by internal steel sprockets and chain from back axle; number of corduroys, four. The front axle suspension is three point for traveling, and the upper frame is rigidly held in position by jack nuts when working. The back or driving axle is a solid steel forging, and the front axle built up of 12-in. I-beams with stubb ends for removing in case of wear. All bearings are provided with the necessary grease or oil cups. All gears of annealed cast steel; spur gearing cut from solid steel blanks. The weight of machine is 30 tons. This machine can be equipped with either steam, internal combustion engine or electricity taken from outside sources or the current can be generated on the machine if so desired. The makers are Pawling & Harnischfeger Co., Milwaukee, Wis.

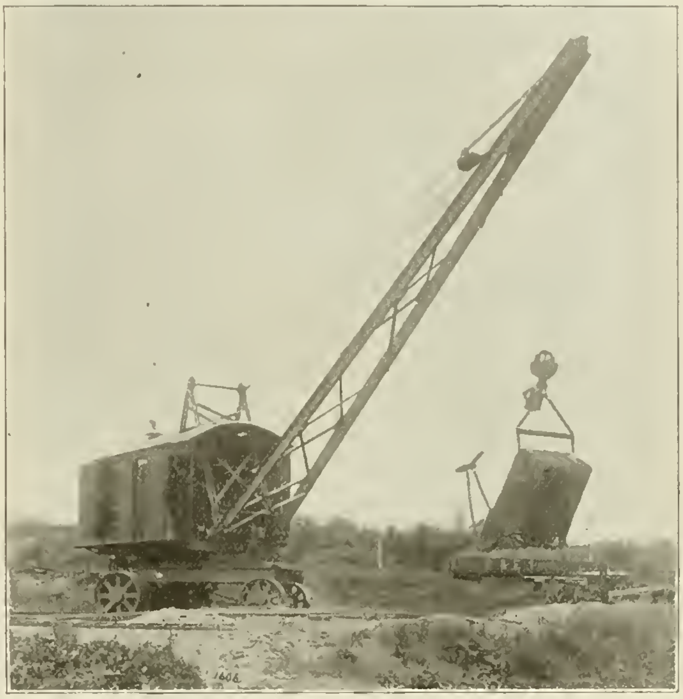


Fig. 2—View Showing Boom and Bucket of Self-Propelling Drag Line Excavator.

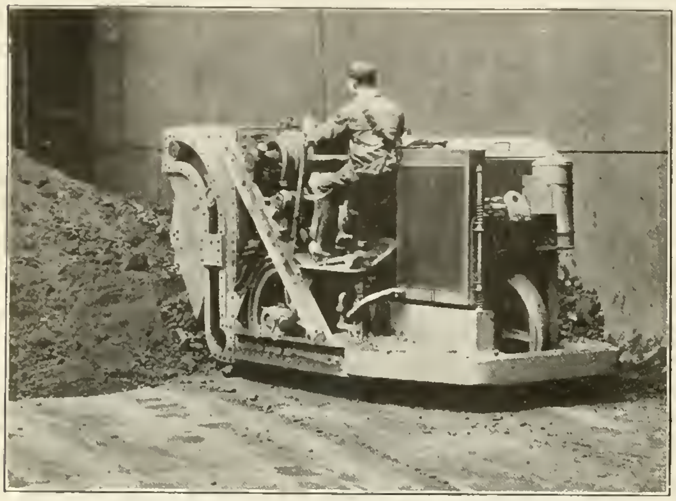
## A GASOLINE POWER SCRAPER SHOVEL FOR HANDLING BULK MATERIALS.

Contributed by Frank C. Perkins, Buffalo, N. Y.

The accompanying illustration shows a gasoline power scraper shovel designed for handling bulk materials of all kinds. The illustration shows the shovel working in iron ore in the hold of a boat, but it can be seen that the shovel can be used for handling various bulk materials. In unloading boats of ore or coal, there is always a certain amount of material that lies between the hatches and cannot be reached by the unloading grabs. The work of the gasoline power scraper shovel is to place this material beneath the hatch openings, thereby doing away with hand shovelers. The gasoline shovel is able to keep enough material beneath the hatch opening to cause the unloading bucket to get a full load at each grab, and deliver the material fast enough to keep the unloading machines busy.

The machine was developed by Mr. S. J. Russell, dock superintendent, on the Buffalo, Rochester & Pittsburgh R. R. Co.'s dock at Buffalo. It consists of a high powered gasoline engine operating a raisable shovel located at the front end of the machine. When the shovel is raised to its top limit it is in a dumping position and the load falls out. The entire mechanism is mounted on two rubber tired driving wheels with a third wheel at the rear as a trailer and steering wheel. The two driving wheels are connected to the engine by means of gearing and clutches so as to travel the shovel back and forth. The hoisting drums for raising the shovel and dumping it are also connected to the engine through gearing and clutches.

All operations are controlled by the operator by means of levers located in front of his seat. Brakes are supplied so as to give the operator better control of the operation. When working in ore and coal in boats, the shovel pushes the material to the desired point, instead of handling it a shovelful at a time. This makes the operation much faster as more material is handled at each trip. When working in the bow, stern or against bulkheads, it is necessary for the shovel to handle the material a shovelful at a time, carrying the same to the hatch.



Gasoline Power Scraper Shovel.

## EXPERIMENTS IN RELIEVING STRAIN BREAKS IN QUARRIES.*

In many quarries, at certain stages in the process of rock removal, expansion of the rock will take place, or irregular fractures will suddenly form, occasionally accompanied by subterranean noises. A modification of methods may become necessary owing to the interference of strain with the successful operation of certain quarry tools. Of still greater importance is the fact that in a number of marble quarries the formation of the so-called "strain breaks" results in the waste of much valuable material. The following basic principles have been established: (1) The causes of strain are not to be found in mere local conditions such as the weight of a nearby hill or the process of surface weathering. Strains are manifestations of the great geologic forces that build mountains and cause earthquakes. (2) In every observed instance of strain the rock has been under compression. (3) The compression is usually in one definite direction. (4) The only way to remove the strain is to bring about expansion of the rock to its normal volume. (5) If the strain on a small mass of rock is relieved, it expands independently of the main mass, with consequent fracturing; therefore relief from strain should be sought for a large mass at one time.

A Tennessee marble company, acting on the advice of Mr. T. Nelson Dale of the United States Geological Survey, made an effort to relieve strain by drilling holes. Although defects were apparent in the preliminary trial, the great increase in the proportion of sound stock produced encouraged a continuation of the method. A complete description of the plan of drilling, effect on the rock, and of suggested changes in method follows:

The mass of rock under observation was 69 ft. long, 20 ft. wide, and 12 ft. thick. It occupied a position along one side of the quarry, the remainder of the floor to the northwest having already been removed. Its position is shown at A in Fig. 1.

A line of holes perpendicular to the supposed direction of compression was first drilled. The holes were $1\frac{3}{4}$ in. in diameter, 12 ft. deep, and the average core thickness between drill holes was fifteen-sixteenths of an inch. The direction of the line was N. 40° W. The line was 20 ft. long, extending from the corner of the quarry along the northeastern wall and terminating at the excavated part of the floor. Its position is indicated by a in Fig. 1.

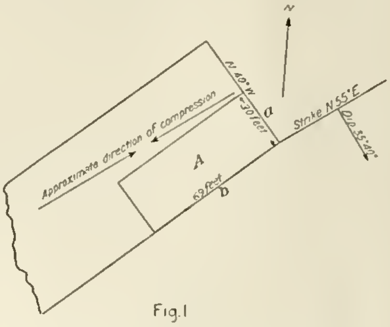


Fig. 1

Fig. 1—Plan of part of a marble quarry, showing position of a rock mass studied. A, rock mass where observations were made; a, position of line of holes driven perpendicular to supposed direction of compression; b position of second line of holes driven to give rock mass freedom to shear on expanding.

A second line of holes of similar depth and spacing was projected along the southeastern wall of the quarry as shown at b. The purpose of this line of drill holes was to give the mass of rock freedom to shear when it expanded. On account of the difficulty of placing drills, holes were omitted for a distance of 10 ins. from the corner on the northeast wall, and 6 in. from the corner on the southeast wall. A mass of rock 12 in. wide was left in the corner.

Expansion of the marble soon manifested itself by a crushing of the cores and a gradual closing of the drill holes. The closing did not take place uniformly. Near the northwestern end of the line it was greatest, attaining a maximum of 7/16 in., which gradually decreased to zero at the other end of the line. There were 88 drill holes in the 20-ft. line. The extent of closing as measured at various points was as follows:

| Hole No. | 1 | 3 | 5 | 10 | 14 | 15 | 17 | 20 | 27 | 36 | 64 | 88 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extent of closing in thirty-seconds of an inch | 12 | 13 | 14 | 14 | 12 | 11 | 10 | 10 | 9 | 5 | 3 | 0 |

The cores were broken the entire length of the line, though the movement in the last holes was too slight to be recognizable with the naked eye. Likewise on the perpendicular line every core was broken by shearing. However, the mass in the corner was unbroken, as far as could be seen, and it would therefore appear that this mass of rock, which was 12 in. in width, effectively prevented the major part of the mass to expand so as to gain relief.

Figure 2 illustrates the second and third drill holes in the cross line. The light line represents the original position of the drill hole walls, and the heavy line the position of the same walls subsequent to the expanding movement. It is evident that motion took place in a diagonal direction, which is undoubtedly due, in part at least, to a lateral slipping of the cores in order that they might gain ready relief by projecting into the open holes. However, the fact that slipping took place toward the corner where a mass of solid rock prevented any movement would

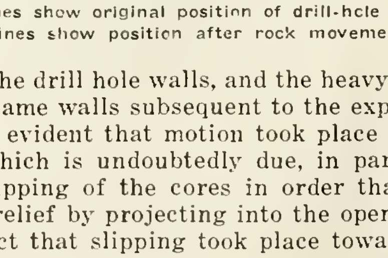


Fig 2

Fig. 2—Second and third drill holes from the left end of the line, illustrating the manner in which the holes were closed by compression. Dotted lines show original position of drill-hole walls; solid lines show position after rock movement.

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*Extracts from "The Tecanology of Marble Quarrying," by Oliver Bowles, Bureau of Mines, Bulletin No. 106.

seem to indicate that the direction of compression was not exactly perpendicular to the line of drill holes, but inclined at a small angle toward this corner.

At a later time a channel cut was made parallel to the first line of holes and 69 ft. distant from it. After the cut had been completed, the fact that complete expansion had not occurred along the first line of drill holes became apparent. That part of the 69-ft. mass that had previously been unable to expand eastward on account of the uncut corner began to expand westward and partly closed the channel cut. The shearing accompanying this expansion broke the cores between the drill holes along the entire shear line, and the displacement gradually increased with the distance from the corner.

Measurements were made of the closing of the channel cut. Owing to a shattered condition of the rock, measurements could not be made nearer than 5 ft. to the quarry wall. At this point the cut was closed 6/32 in., 13 ft. from the wall it was closed 2/32 in., and 18 ft. from the wall it was not closed at all.

Thus it is evident that where relief was gained along the original line of drill holes no further relief was necessary, but where in the original line no motion was possible a backward motion took place as soon as a means of relief was provided.

The suggestions following are offered with a view to improving the method of quarrying already outlined.

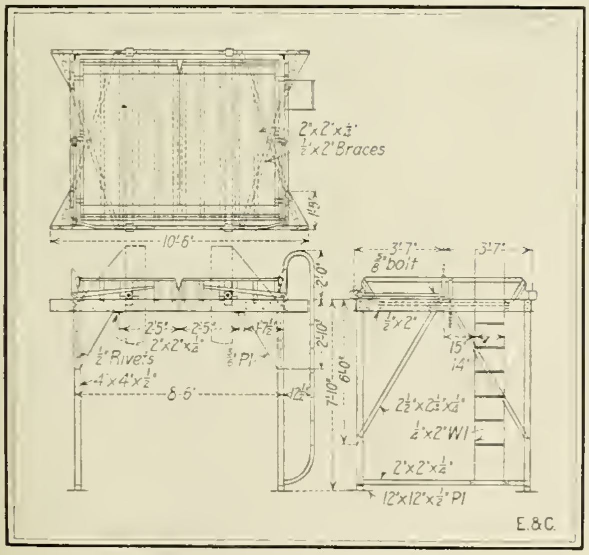
(1) If it is impossible to complete a line of drill holes in a corner, the corner should be cut across diagonally with a closely spaced row of holes in order that no mass too great to be crushed may remain.

(2) To avoid delay by jamming of the drills, the shear-line holes should be made first, as no appreciable movement of the rock will take place until the cross line of holes is projected.

(3) If drilling costs seem to justify it, holes should be more than 12 ft. deep, as the object to be continually kept in view is to gain uniform relief at one time for as large a mass of rock as possible.

## DUMPING TABLE FOR LOADING WAGONS IN EXCAVATING BUILDING FOUNDATIONS.

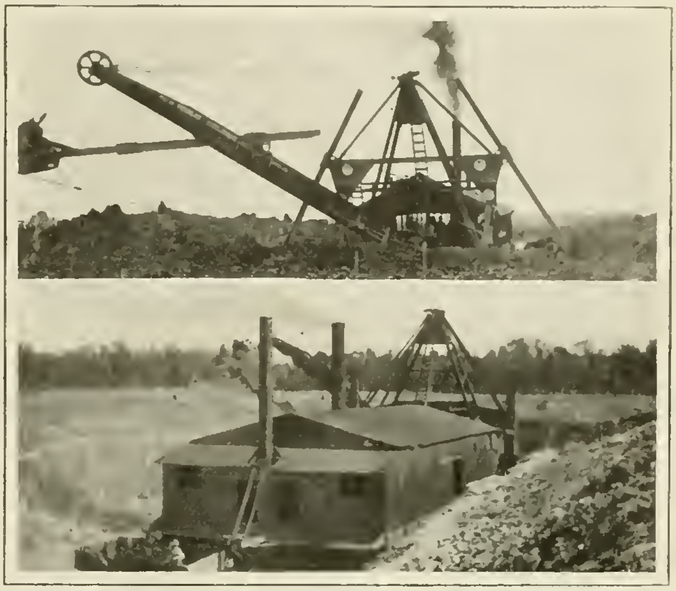
The dumping table illustrated was used in excavating a large business block basement from which the spoil was handled in buckets by derrick. The drawings indicate clearly the main structural features of the table. In operation the derrick unloaded the buckets of spoil onto the hinged pans or tables and wagons driven underneath were loaded by unlatching the pans which then automatically tilted, emptied and returned to loading position. In discharging the pans nicely "trimmed" the load in the wagon and the amount spilled was very small. One man attended the table. When a change of position was necessary the derrick lifted the table bodily. The table was found to be a most economical and easily operated device by the contractors, the E. J. Cook Co., Portland, Ore.



Dumping Table for Loading Wagons.

## A NEW KNOCK-DOWN STEEL DREDGE.

A steel dredge built, including hull, to be shipped in knock-down form and erected on the work, is illustrated by the accompanying engravings. Figures 1 and 2 show the general appearance of the new machine. The hull as indicated by Fig. 3 is made up of flat steel sections and it is stated that all the sections for an 80x20x6-ft. hull can be loaded on one flat car. On a drainage ditch job an 85,000-lb. hull was hauled from cars to bank in two days at a cost of about $60. To erect the hull required about 790 man hours, including 1½ days' delay and cost $140. Two features of the front end construction of the dredge are unique. The boom and the circle are separate pieces, and the clipper handle is composed of two welded steel channel box girders, as shown by Fig. 4. To form a box girder two channels are set flange to flange with the dipper hinge casting inserted and bolted in place; then the channels are oxy-acetylene welded edge to edge of flanges, making a rivetless member. The two box-girders are then bolted together through fillers, as shown, and the rack is bolted in place as with the ordinary wood handle. In the new dredge also several changes have been made in minor details intended to stiffen and



Figs. 1 and 2—Front and Stern Views of Steel Knock-Down Dredge.

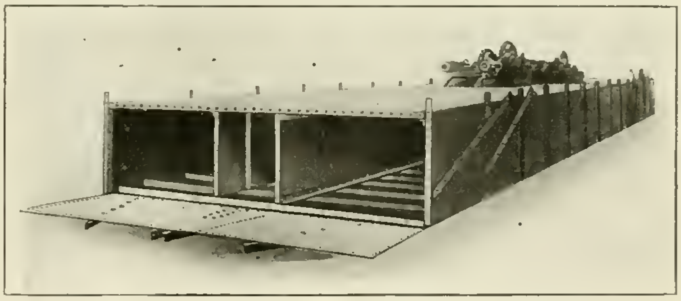


Fig. 3—Steel Hull for Knock-Down Dredge.

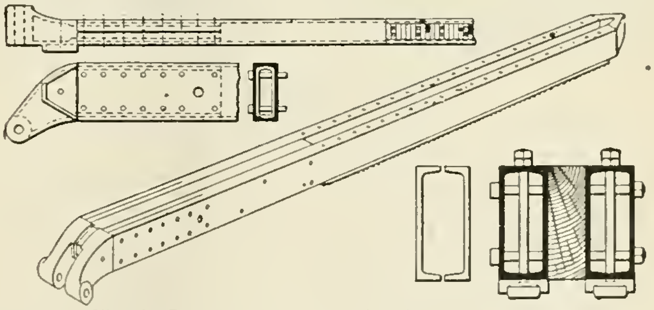


Fig. 4—Dipper Handle for Knock-Down Dredge.

strengthen the machine. The makers of this dredge are the American Steel Dredge Co., Ft. Wayne, Ind.

## NEW EAST RIVER TUNNEL, NEW YORK CITY.

The Public Service Commission for the First District, New York City, has received bids for the construction of the last piece of under-river tunnel construction yet remaining to be placed under contract in connection with the new dual system of rapid transit. This is the new two-track tube under the East River from Second Ave. and 60th St., Manhattan, to a connection with the new elevated lines in Queens at Queensboro Bridge Plaza Station. The tunnel will connect the Queens Lines with the route under 59th St. and Central Park West, which is to connect the Broadway-Seventh Ave. line in Manhattan to be operated by the New York Municipal Railway Corporation. The latter corporation is to have trackage rights over the Queens Lines, terminating respectively at Corona and Astoria. The low bidder on the tunnel work was Patrick McGovern & Co., of 1 Madison Ave., New York City, whose bid was $4,194,797, which is considered a reasonable bid for under-river tunnel work. The Degnon Contracting Co. of 30 E. 42d St., New York City, last year made an offer to build the tunnel for $4,500,000 in the event that certain changes were made in the contract held by Degnon for the sections immediately to the west of the tunnel in Manhattan, reducing the amount of work to be done there. In the bid on the tunnel, however, the Degnon company went below its proffer by $253,000, but was more than $50,000 over the McGovern bid. The tunnel work is a part of Route No. 61 adopted by the Commission on July 28, 1915, following the decision of the Commission made at the request of the Board of Estimate and Apportionment to abandon the route over the Queensboro Bridge as a part of the line to connect with the Queens Lines. The Degnon proposition contained the suggestion that the route be changed from bridge to tunnel. City officials had estimated that $2,000,000 or more would be necessary to alter the Queensboro Bridge sufficiently to carry the heavy weight of the all-steel subway trains. If the cost of these alterations to the bridge is added to $500,000, which the Degnon company agreed to cut from this contract on the 59th St. and 60th St. Line in return for a change in route and deducting from the McGovern bid for the tunnel, the remainder represents approximately the net additional cost to the city through the construction of a tunnel instead of utilizing the bridge route.

The tunnel extends easterly under E. 60th St. from Second Ave., Manhattan, beneath the west channel of the East River, Blackwell's Island, the east channel of the East River, waterfront property in Queens Borough, under and across Vernon Ave., through private property under N. Jane St. and under the Queensboro Bridge right of way, ending at the Bridge Plaza Station at a point between William and Crescent Sts. The tunnel comes to the surface near Hancock St. in Queens and will be an open cut from that point to near the Boulevard and Sherman St., and thence will extend by elevated structure to the connection with the Bridge Plaza Station. Permanent ventilation shafts are to be provided on Avenue A in Manhattan and on Blackwell's Island. The successful bidder is allowed 30 months in which to complete the work.

## NEWS LETTERS.

### St. Louis Items.

A. Bean, Pekin, Ill., has a small team outfit that he wants to work by the day.

J. W. McMurray came in from Oklahoma, returned to Kansas City. Nothing new.

Cook & Waddell are doing some bank widening for the Rock Island R. R. through Iowa.

E. E. Headley & Son, Marion, Ill., wants 2 or 3 small team outfits for county road work.

F. W. McElroy is going to begin work on a street paving contract at Robinson, Ill., in a few days.

Dudley Smith has finished his work on the Burlington R. R. at Benton, Ill. Has 10 teams idle.

Sheahan Bros., 114 Kentucky Ave., Danville, Ill., have 35,000 yards of team work to let at that point.

Chas. E. VanWormer, Springfield, Ill., can use some team outfits on several different road jobs in Illinois.

A. V. Fetter & Co. will begin on their Government revetment and rip-rap job on the Mississippi River next week.

Mulvill Bros., Alton, Ill., has a small force account job on the Chicago & Alton R. R. in western Missouri to sublet. They are going to finish their job on the Burlington R. R. at West Alton, Mo., two weeks ahead of contract time.

McCann Bros. Const. Co., Grand Tower, Ill., have 50,000 yards of levee work in Union County, Ill., to sublet. They have until Jan. 1, 1917, to complete this.

Wm. C. Reed, after an absence of over three years from St. Louis, returned here last Friday. Reed has been superintending a lot of bridge and concrete work in Texas.

Hampton & Hodge, 20th and Washington Sts., Granite City, Ill., are in the market for a timber clearing job. They just finished a big job of this kind at Wolf Lake, Ill.

A. E. Koenig and family spent last week in Chicago. Koenig missed calling on a whole lot of his friends while there, but will do so on his next trip, which will be in a couple of weeks.

W. P. Rood, manager, and T. E. Brogan, the hustling representatives of the Hercules Powder Co. here, gave us a pleasant call one day last week. Lots of business and looking for more.

Chas. Nagel is moving a part of his big rock outfit to Calhoun County, Ill. Is going to furnish rip-rap to the Government on the Mississippi; also to A. V. Fetter & Co. during the season.

The Terminal Railroad Association of St. Louis has acquired five additional blocks of ground in North St. Louis, and is going to improve these with additional switches and tracks immediately.

Carter Const. Co., 2015 Railway Exchange Bldg., St. Louis, Mo., was awarded the contract for an eight-mile extension of the Big Four R. R. near Harrisburg, Ill. It has 130,000 yards of grading to sublet on this line in quantities to suit outfits.

B. F. Bush, receiver of the Missouri Pacific-Iron Mountain System, and E. J. White, solicitor for the receiver, were in Joplin, Mo., on Monday for a conference with city authorities and leading commercial interests there relative to a new passenger depot and freight depot which the company intends to erect there. The improvements will be modern in every detail, and greatly increase the facilities for handling traffic. The two depots will cost approximately $100,000.

A. B. KOENIG.

## PERSONALS.

Charles A. Winston has been appointed town engineer and surveyor of West Orange, N. J.

Frank V. P. Ellsworth has resigned his position as assistant city engineer of San Antonio, Tex.

The Providence Engineering Society of Providence has opened club rooms at Waterman and Benefit streets.

S. C. Moore, secretary of the Commercial Club of Glasgow, Mont., has been appointed city manager of that city.

Fred Slater has been elected vice-president and general manager of the Texas Light & Power Company of Dallas, Tex.

Frank G. White has been appointed engineer of the State Board of Harbor Commissioners of California, with headquarters at San Francisco.

Mayor R. D. Waugh of Winnipeg, Man., has been appointed chairman of the Commission of the Greater Winnipeg Water District, succeeding the late S. H. Reynolds.

Myron A. Bantrell has been appointed engineer and chemist of the Brighton sewage disposal plant of Rochester, N. Y. Mr. Bantrell has held a temporary appointment in this position for some time.

George D. Marshall, United States Office of Public Roads, has been assigned to Texas, under the direct supervision of the Governor, to act as state highway engineer as far as the present law of that state will permit.

Thomas G. Bush, formerly assistant state highway commissioner of Washington, is now engaged in the contracting and wholesale building material business, with offices in Spokane. The firm name is Thomas G. Bush & Co.

C. D. Livingston, heretofore instructor of agricultural engineering of the University of Wisconsin, has been promoted to the rank of assistant professor. Herbert D. Orth, instructor in engineering, also has been promoted to the rank of assistant professor.

R. B. Murdock, roadmaster of Coos County, Oregon, has been appointed assistant engineer for the State Highway Department, and will have charge of surveys to be made for highway work in this county, for which a bond issue of $362,000 was voted recently.

E. W. Scheer, Superintendent of the Indiana Division of the Baltimore & Ohio Railroad, with headquarters at Seymour, Ind., has been made general superintendent of the system, with headquarters at Cincinnati, succeeding R. N. Bergien, promoted to be chief engineer of the railroad.

L. B. Allen has been appointed general superintendent of the central division of the Chesapeake & Ohio Railroad, succeeding J. Paul Stevens, who has been promoted to general manager. For several years past Mr. Allen has been division engineer of the railroad with headquarters at Ashland.

Joseph A. West, formerly chief engineer of the Ogden Rapid Transit Company of Ogden, Utah, and the Ogden, Logan & Idaho Railway, has been appointed chief engineer of the Sumpter Valley Railroad of Oregon, and will have charge of the survey and construction of several important extensions into the timber country.

A. M. Morrison of the Canadian Engineers of the British Army, has been awarded the Distinguished Conduct Medal for conspicuous gallantry. He also has received a commission as lieutenant in the Canadian Engineers. At the outbreak of the war Mr. Morrison was an engineer engaged in the construction of the Pacific Great Eastern Railway in British Columbia.

The State Association of Planning Commissions of Pennsylvania has been organized. A. B. Farquhar of York, Pa., is president; Edwin S. Herman, chairman of the Harrisburg Commission, is vice-president; J. Herman Knisely, chief of the division of municipal statistics of the State Department of Labor and Industry of Pennsylvania, is secretary; John K. Stauffer, Reading, Pa., is treasurer.

R. E. Koon, of J. B. & R. E. Koon, civil, hydraulic and sanitary engineers, Portland, Ore., will have personal charge of the engineering work during the construction of the new municipal water supply pipe line for the City of Everett. The line will conduct water from the Sultan River to the city, a distance of 26 miles. The cost of the project will be about $600,000 and will probably be completed in the fall of 1917. Contract for the work was let on June 5.

## OBITUARY.

Charles Anderson, a highway contractor, died July 8 at his home at Ellensburg, Wash.

B. Franklin Bonham, a general contractor of Philadelphia, Pa., died July 8 at his home in that city, at 5003 Catharine street.

M. A. Pigott, a well known railway and building contractor of Hamilton, Ont., died suddenly, July 5, at his home in Hamilton.

Alfred O. Kemmer, a mining engineer of Chicago, was drowned July 4 while swimming in Olympia Park Lake at Nevada City, Cal.

J. Crowell Mundy, formerly general superintendent of works of Newark, N. J., died July 10 at his home, 259 Belleville avenue. Mr. Mundy also was formerly engaged in the general contracting business.

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., JULY 26, 1916. Number 4.

## ANNOUNCEMENT OF THE BUILDING AND STRUCTURAL MONTHLY ISSUE OF "ENGINEERING AND CONTRACTING."

Beginning this issue all articles relating to what may be broadly designated as structural engineering will be published the fourth Wednesday of each month. This will be known as the Building and Structural Monthly issue of "Engineering and Contracting."

Structural engineering is perhaps not an ideal term, since an earth embankment and a pavement are quite as truly structures as are buildings and bridges. But the term structural has come to have a more restricted meaning in engineering parlance than in general usage. Structural engineering embraces the design and erection of all framed structures to which the science of strains and stresses is applicable, such as roof trusses, beams, columns, bridge trusses, arches, towers, etc.

The structural engineer at present works mainly with steel as the skeleton part of the structures. But the investiture with which the skeleton is clothed may be varied—concrete, tile, stone masonry, what not.

When the structural engineer confines his work to buildings only, he is often called an architectural engineer, and when he specializes in bridges he is a bridge engineer, those being the two largest branches of structural engineering.

There has been no periodical devoted to structural engineering. In common with other civil engineering papers, "Engineering and Contracting" has for ten years published articles every week on structural engineering topics. But we believe that an era of development toward a more specialized publication is about to begin, and that a periodical devoted entirely to structural engineering should now be issued. Accordingly it has been decided to devote to the fourth issue of "Engineering and Contracting" each month to articles on structural engineering, and to call that number the Building and Structural Monthly. The subscription price of this monthly issue is $1 a year, but, as stated on the front cover, it may be secured in combination with any of the other three monthly issues of "Engineering and Contracting" at 75 ct. each per annum.

The construction news will of course continue to be published weekly, and this, together with the four specialized issues of articles each month, can be secured for $3 a year.

In the future as in the past we shall not confine our articles to the design of structures, but shall discuss methods of erecting them, giving considerable space to illustrating and describing erecting appliances, methods and costs. For the most part the articles will be short, each dealing with a specific problem. It is hoped thus to be of greatest aid to the busiest structural engineer and builder.

We realize that upon starting this type of monthly article service in this field we shall not immediately attain even our own ideals. But with the aid of the kindly criticism of our readers we shall unquestionably come progressively closer to our goal.

## A PASSING GENERATION.

The Pennsylvania Co. has begun reconstruction of its bridge across the Ohio River at Louisville, Ky. At Cincinnati, O., the Cincinnati, New Orleans & Texas Pacific Ry. is rebuilding its bridge across the Ohio River. The reconstruction has recently been completed of the Keokuk, Iowa, bridge crossing the Mississippi River. The Louisville Bridge was built in 1869 by Albert Fink, that at Keokuk was completed a year later, 1870, by J. H. Linville. Mr. Linville also built the Cincinnati Bridge in 1877. Fink and Linville and their truss-systems and their long lists of bridges built belong to a passing generation. In a great book on bridge engineering just published the author, a noted bridge engineer, says: "A modern steel bridge carefully designed by a first class bridge engineer, constructed under proper supervision and thoroughly painted from time to time, will last for an indefinitely long period, even if it be materially overloaded." So believed the bridge builders of the seventies, with less justification perhaps, but just as earnestly.

## HYDRATED LIME IN CONCRETE BUILDING CONSTRUCTION.

No admixture to cement for concrete construction has met with greater general favor in recent years than hydrated lime. It is a commercial product promoted by an unusually alert publicity bureau. The promotion work has advanced the use of the material, and also, as all vigorous promotion does, has given it somewhat the reputation of a nostrum. This is an unfortunate occurrence. Engineers are wary of anything that smacks of a cure-all. Entirely wrongly, we believe, hydrated lime has obtained this savor, and as a consequence its use is shunned often when it would serve an excellent purpose. Hydrated lime is a building material as natural in origin and in production as is cement. It is even more free from active destructive effects upon other materials normally used in combination with it in building than is cement. Combined with cement hydrated lime is technically an adulterant. Here, again, its appellation has begotten fear. Adulteration has, for obvious reasons, become anathema. Nevertheless adulteration often serves a good purpose. Steel to which a small percentage of nickel has been added is in a sense adulterated steel; yet for many purposes it is a better material than "straight" steel. Portland cement to which hydrated lime has been added is similarly an adulterated cement, but it has qualities which the "straight" cement does not have. Mixed with water and sand it furnishes a much smoother working mortar. A concrete made of it is denser and more impervious; it is less likely to suffer segregation in handling and placing; it runs easier in chutes and spouts; it works better into the forms. These are all demonstrated facts, and they are facts of importance to the concrete builder. They should excite his attention to the possibilities of service which hydrated lime offers.

## A PROPOSED AMERICAN SOCIETY OF STRUCTURAL ENGINEERS.

Along with the tendency to consolidation of engineering societies there remains an even greater tendency to increase the number of special technical associations. This is evolution—integration concurrent with differentiation. For certain purposes all engineers should unite. For other purposes they should act in separate groups.

There are societies of road builders, of municipal engineers, of water works engineers and managers, of railway engineers, and, indeed, of every major division of civil engineering practice save one—structural engineering.

We believe the time is ripe for the organization of a national society of structural engineers.

Structural engineers engaged in the design and erection of buildings have long felt the necessity of organized effort to secure much needed recognition both from legislators and the public. In many states there are laws that prevent any one save a "licensed architect" from having charge of the design of large buildings. Such laws are the relic of a pre-engineering age, and should either be changed materially or abolished entirely. A strong association of structural engineers could soon bring about the desired changes in restrictive statutes of this sort.

There is of course a much greater need of collective action on the part of structural engineers to educate the general public, and particularly that part of the public called "owners," as to the limitations of most architects and their dependence upon structural engineers in designing nearly all types of commercial buildings. Reinforced concrete and steel-frame buildings were originated by American engineers, and their introduction was effected mainly through the individual efforts of structural engineers and builders, architects assisting but little in persuading "owners" to adopt these types of buildings.

Although many "owners" have come gradually to recognize the fact that about 90 per cent of the designing of a commercial building consists in solving engineering problems, and although many engineers are now acting as architects of such buildings, there still remains a big educational task to be undertaken by those who hope to see structural engineers in more general managerial charge of the design of commercial buildings. This educational work alone justifies the existence of a national society of structural engineers.

We believe that with the growth of public opinion favorable to placing the design of commercial buildings in the hands of engineers there will follow many radical innovations in the design of other buildings, such as residences. The training of architects always has been and still remains largely a training in art as applied to building design. This is well brought out by such statements as the following:

> Vitruvius lays down three qualities as indispensible in a fine building: stability, utility, beauty. From an architectural point of view the last is the principal, though not the sole element; and, accordingly, the theory of architecture is occupied for the most part with æsthetic considerations, or the principles of beauty in designing.—Encyclopædia Brittanica.

But we need not turn to the latest encyclopedia for an authoritative expression of what constitutes the predominant element in architectural training. It may perhaps best be seen in current architectural magazines, whose main appeal is through handsome halftones and beautiful sketches.

Our purpose is not to decry art in any form, but we do insist that it is really as incongruous to commission an architect to design a railway bridge as to design a mill building. Art in commercial buildings should be subordinate to economic utility. The engineer is primarily an economist, and in almost every other engineering field save building design, engineers have gone a very long way toward convincing the public that to engineers should be intrusted the design of those structures and machines that are to serve a commercial purpose with greatest economy.

Herbert Spencer in his essay on "Education" said that ornament preceded utility in the evolution of clothing and that the same order of evolution is to be seen in education. While buildings were probably first evolved by erecting walls across the mouths of natural caves, and therefore in that case utility preceded ornament, in the course of time art began to overshadow utility. Witness most of our public buildings to this day—piles of stone, extravagant in cost, seldom suitable for their functions and always costly in the extreme.

The time has come to put more engineering into all kinds of architecture. To accomplish this end we must put more engineers into the building field, both as supervisory designers and as contractors.

The editor will be pleased to hear directly from all those who are interested in the foundation of a society of structural engineers. Suggestions as to its organization and its functions should be given. If the response to this appeal warrants such action, the editor will give further publicity to the project and will issue a call for applicants for membership.

## BRIDGE TESTS AT THE MINNESOTA STATE FAIR.

A State Fair bridge test is one of the educational "stunts" of the Minnesota Highway Commission and one which seems deserving of imitation by other state road departments. Briefly, the engineers of the commission have built on the State Fair Grounds a concrete bridge and during the week of the fair experts from the Experimental Laboratories of the University of Minnesota will conduct tests daily, the final test on the last day of the fair being a destructive load to exhibit ultimate strength. As the test proceeds from day to day the results will be bulletined. While the highway commission engineers expect to gain from the test information which will be of aid in developing standard plans the main purpose of the test is to give township and county officials visual evidence of the strength, appearance and economic merit of bridge construction of permanent character.

## THE STRUCTURAL ENGINEER AND HIS FUTURE.

The early schools of civil engineering gave precedence to structural engineering over all other branches of civil engineering. This arose quite naturally from the fact that mathematical analysis was not applicable to as great a degree in any other branch, if we except hydraulics. Consequently bridge engineering counted among its specialists many of the ablest graduates of those early engineering schools.

With the growth of large bridge companies and the coincident standardization of bridge plans by railway companies, came a wave in prosperity for most independent engineering practitioners who specialized in bridges. But about the same time there began to emerge a new type of engineer, the "architectural engineer," who saw in the growing use of steel and concrete for buildings a chance to create a profitable market for his services. Structural engineering applied to buildings has steadily increased in importance and is destined to revolutionize all architecture, even that relating to the smaller residences and commercial buildings. We believe, in fact, that structural engineers may confidently anticipate an era of great prosperity for executive engineers engaged in the design and construction of buildings of a "fireproof type"—those made of reinforced concrete, steel frame, tile, etc.

Two steps should soon be taken toward accelerating prosperity in the structural field.

First, there should be organized a national society of structural engineers. Second, campaigns of publicity should be undertaken to hasten the elimination of buildings that are not fireproof or fire resistant.

## ENGINEERING GRADUATES FAITHFUL TO ENGINEERING.

Only one engineering school graduate out of ten follows another vocation than engineering and only six out of ten leave their home states to practice their profession. These figures are only approximate, but they are based on more precise data collected from some fifty engineering colleges by Professors Patten and Bowerman of the Kansas State Agricultural College. Exactly 90.1 per cent of the graduates of the fifty engineering schools included in the investigation remain in the occupations for which they were prepared. Geographically the variation is as follows: North Atlantic states, 87 per cent; South Atlantic states, 85 per cent; North Central states, 94 per cent; Western states, 86 per cent, and South Central states, 90 per cent. The numbers of graduates remaining in their native states after graduation are, respectively: 42 per cent, 44 per cent, 41 per cent, 43 per cent and 27 per cent. The percentages are not particularly illuminating except in their certain demonstration that engineers are remarkably faithful to their schooling and are not nearly such migratory beings as is frequently assumed.

## THE HOUSE THAT ENGINEER BUILT.

Everyone knows the story of the house that Jack built. This is the story of the house that engineer built and it has never before been written. Engineer was young and his ambitions in regard to a house were modest because all engineers are modest and this engineer had also a modest income and a modest bank account, and war was abroad in the world and hopes of the near future for activity in the peaceful pursuits of engineering were modest. Engineer had given a hostage to fortune and with a provident eye to the future wanted a house with a good safety factor of roominess—such a factor as would postpone functional obsolescence until means had accumulated for reequipment. Architects and builders stood eager to serve, but their service could not be equated with Engineer's financial possessions and expectations. They could think only in terms of results. Engineer must think also in terms of means; of how to do well with one dollar what the builder and the architect were willing to attempt with two dollars. And naturally he thought as an engineer. Here, said he, is essentially an engineering structure designed to be architecturally sightly. How without altering the sightliness that the architect has given it can I better the engineering of this structure? I will analyze and redesign. And Engineer did so. Here he substituted a girder for a wall, there he reduced a section by a stiffener or a strut, and so with many devices he decreased materials and labor. Then he made new structural plans in detail. If this house were a bridge, said Engineer, I should so schedule my material and structural parts that nothing or, at most little, should come onto the work for which there was not a place in the bridge and everything possible should come onto the work in such form that it would fit exactly its place. Also I should have the mill assemble the parts in the largest units possible to ship to the work and readily to be handled on the work. I will try the same plan with my house, said Engineer, and he did. Then he went to a builder and hired him to erect the house and the house was built and the editor who lived across the way watched the building and talked with Engineer and his builder. Said the builder: "It is the neatest job I ever did. That house went together like a child's puzzle game. There wasn't a cart load of waste. And I made good wages." Said Engineer: "How much do you think the house stands me in? Five thousand dollars? Well, materials and wages have gone up, but Mr. Builder and I will duplicate the house for you for $4,600 and take our chances at making wages out of the job." And the editor, listening and, as is the nature of editors, thinking how this that he had witnessed and heard might be utilized in fabricating his weekly offering to his subscribers, decided to tell the story. And now the editor asks: If Engineer was able to save for himself by better engineering design and planning, say 10 per cent in the cost of a $5,000 house, why should he not as a house builder be able to save some part of this percentage for a client? He is able, for this house as planned originally was no different, at least no worse, as an engineering structure than thousands of houses that are planned every year. Why then should not engineers find profitable opportunity in house building? As we have said elsewhere in this issue, we believe that they should find this opportunity in all kinds of building construction.

## HIGH WAGES IN CHICAGO.

In Chicago, and indeed in all the very large cities, the wages of workmen employed by public works contractors have attained a level so high as to make many a civil engineer envious. For example on a brick sewer job the contractor is now paying the following wages per 8-hr. day: Bricklayer, $10; shovel engineman, $8.33; dinkey engineman, $6; men trimming trench sides and bracing, $4.60; laborer; $3.20.

Only a few years ago skilled drillrunners, carpenters and other "mechanics" were envied by laborers for their "three per," and now those laborers are themselves in the high-wage class and kicking for more. They will ultimately get more and they will deserve to if they join the efficiency movement, doing all in their power to aid in the introduction of labor saving methods and devices.

## THE COMMERCIAL DESIGNER-BUILDER OF REINFORCED CONCRETE BUILDINGS.

Francis Hennibique in Europe did more perhaps than any other one man, perhaps more than all other men, in the early days of the new material two decades ago to place reinforced concrete building on a parity with building construction of older materials and forms. In America, Ernest L. Ransome performed much the same task that Hennibique performed in Europe. Both of these men were designer-builders. We might almost call them merchandisers of buildings. They designed and constructed buildings to order and they also by promotion and advertising developed the orders. Hennibique in Europe and Ransome in America were followed by a host of others in the field which they had exploited. Names that occur out of hand are Leonard Wason, the Turner Construction Co., the Kahns of Detroit, the Ferro-Concrete companies of Baltimore and Cincinnati. All of these builders are yet in the field and the structures that are their work must number into the hundreds. With rare exceptions also these structures are of a character to which any builder might point with satisfaction.

Nine years ago in these columns we wrote in defense of these commercial designer-builders in reinforced concrete and demanded as their right high merit for the development of reinforced concrete as a practical and economic construction for buildings. In this, our first Bridges and Structural monthly issue, we wish again to ask their just meed of praise for these men and to present their example as argument for assumption by the engineer of his rightful place in building construction. The men named and the men who captained the firms named above were engineers before they were building contractors. They became building contractors because in this way only could the new building material, the possibilities of which they as engineers forsaw, obtain a hearing and recognition. With architects it was taboo. Building departments gave it reluctant recognition only after years of struggle. Ransome and Turner and Wason and Kahn and Anderson and men of their brotherhood established reinforced concrete as a building construction material in America. They did it as commercial designer-builders. To the architect the accomplishment owes practically nothing. Even in his own field of aesthetics he has been a follower in developing the opportunity which the plasticity of concrete offers for beautiful line and surface. Most of the real art development in concrete has come from our city park departments and the commercial producers of cast stone.

The engineer is the logical building constructor. His is the knowledge of structural forces and of the principles of balancing them, and his is the knowledge of the structural qualities of materials. Herein is the reason why the engineer perceived the possibilities of reinforced concrete for buildings and the architect did not. Herein also is the reason why, if building structure is to advance, the engineer must be the pioneer. Why should he not reap the rewards of his labors by assuming the work of building. Because he did this in reinforced concrete building we have a high development within a score of years of that type of building. The engineers whose names we have written and their disciples deserve credit for a great accomplishment—they pushed outward the boundaries of opportunity for the engineer.

## "BRIDGE ENGINEERING."*

It seems now a long time since there came to the writer's desk for review a small book bearing the curious title "De Pontibus." The book was pocketed, and at odd moments on train and in hotel rooms during a succeeding business journey it was read. Eighteen years later the confession will not be taken amiss that the reader was perplexed by the book. Habituated to the conventional text book on bridges then universal and since not too often varied, the virile individualism of "De Pontibus" required association to establish the volume as an entirely proper acquaintance. Always the invitation to a knowledge of bridge engineering had been couched in formal third person; here was a writer who used the colloquial first person in bidding one to his table. To be sure the entertainment was lavish, but was it quite proper form for the host to assert its qualities? Is this a fanciful reason for the "caution" with which "De Pontibus" when first published was greeted? Perhaps; yet the writer has come to believe that it was the greater part of any reason that existed. These first impressions of "De Pontibus" are recalled at this time because its gifted author now addresses his profession in a much greater book called "Bridge Engineering"—a sublimated "De Pontibus."

"Bridge Engineering" the author considers "to be the most important work of his entire professional career." In it the author has aimed to give his readers "all the information that he has been able to accumulate during a practice of forty years." These statements presage a book of size. "Bridge Engineering" is a very large book—80 chapters, 2177 pages, 1,000,000 words, 540 illustrations, 90 tables are the enumeration. Further cataloging of contents goes beyond our space. Moreover, such a measure of the book no more expresses its real character than does the cubature of a man's brain define his personality and his predominant intellectual possession.

The outstanding feature of "Bridge Engineering" is the catholicity with which its subject is regarded. A bridge engineer is many things besides a technician. He is a promoter, a business man, a financier, an economist, an employer, an arbitrator, an artist, a conservator of professional ethics and a man. In this book his manner of performing all these roles is considered. Its chapter titles include Ethics of Bridge Engineering, Bridge Engineering Fees, Arbitration, Promotion of Bridge Projects, Responsibility of the Bridge Engineer, with the more usual titles, Methods of Stress Computation, Impact Loads, Deflections. The author tells how to analyze stresses, but he also tells what one's duty as a bridge engineer is to assistants, to the public, to his client and to himself. His discussion of secondary and indeterminate stresses is precise, but no more carefully so than his discussion of the legal, financial and moral responsibilities of bridge engineers. These things make this book a treatise on bridge engineering which is much more than a treatise on bridge design and construction.

Second only to its scope is the liberality with which "Bridge Engineering" bestows its author's accumulation of working data. The volume of these alone would make any book on bridges notable. No count is practicable of the contained tables and diagrams of costs, loadings, weights, quantities and economic functions, but they run well into the hundreds. This feature of the book stretches its usefulness beyond the bridge engineer as a technician to the executive heads of railways and municipalities—to presidents, general managers, mayors and public works department heads. As a book of reference "Bridge Engineering" presents a wider claim for use than do books more closely confined to the technicalities of bridge design and erection and of materials of construction.

"Bridge Engineering" is called in a preceding paragraph a sublimated "De Pontibus." It exhibits the same individuality of thought, the same personal outlook, the same candid self-esteem. It is just as frank in its condemnation and praise, and just as bold in its advance beyond accepted practice. Its style is of the same naivete. To the reader surfeited with engineering literature shorn of every phrase and word not a mechanical necessity to comprehension, this free style is welcome. One feels as if listening to the functioning in speech of the human mind, and not merely witnessing the functioning in printed characters of a computing machine. One likes, even in a technical treatise, enough garrulity to let him touch something of the personality of the author. A text book of bridge engineering has as little individuality usually as a table of logarithms, which does not make it a better text book and does make it a book decidedly uninteresting to read. It may not be vitally important to the usefulness as a tool of an engineering book that the author inject into the text personal comment and little confidences of opinion: the book is no more true because it includes these aside remarks, but it is more humanly interesting, and it is not a whit the less true.

"Bridge Engineering" possesses another characteristic that merits notice. It is to an unusual extent a record of personal performance. When essential the author has gone outside his personal practice for example and illustration, and, of course, in presenting the theory of stresses and other similar information he has drawn on common knowledge, but the greater part of the examples, illustrations, working data, office forms, specifications, and other facts presented is from his own experience. And, as has been said, the opinion and comment are peculiarly the author's own. This, again, is a variation from the normal in the production of engineering treatises.

The publishers have catalogued the contents of "Bridge Engineering" in liberal detail; some 60 printed pages are occupied by the schedule, and to them is referred the reader who wishes this particular information. To whom should the book prove useful? is a question, however. which all proper book reviews are expected to answer. It has been said that it should prove useful to executives and managers not professional engineers, but having decision on or direction of expenditures for bridge construction. It should prove useful to bridge engineers for reasons indicated previously and for these following specific reasons: The principles of bridge design and construction are explained and exemplified. With the various tables and diagrams a close estimate of cost of nearly every kind of bridge can be made. The economics of alloy steels for heavy and long spans are demonstrated. A practical treatment is presented of determining secondary, temperature and indeterminate stresses. The protection of metal work is expounded; the design of reinforced concrete bridges is explained; all kinds of substructure are described and illustrated; quantities of materials, weights and costs for all kinds of bridges are given; office systems and field engineering operations are described; administration of bridge work, ethics of bridge engineering, responsibility of bridge engineers are considered; complete specifications are given for all kinds of bridges and viaducts. The book closes with a remarkable glossary of technical terms used in bridge work and with an ample index.

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*Bridge Engineering.—By J. A. L. Waddell. Two volumes. John Wiley & Sons, New York. Cloth 6x9 in. 2177 pp.; illustrated; $10.

## SOME NOTES ON PILE DRIVING.

Contributed by L. G. Hall, C. E., Marcus Hook, Pa.

During the past winter and spring, a dock has been under construction by John Monks & Sons, contractors of New York, at a large manufacturing plant on the Delaware River below Chester, Penna.

To provide for possible future dredging and construction, it was considered necessary to drive the piles to a depth of at least 30 ft. below mean tide.

The job involved the driving of some 2,400 southern yellow pine piles in the river bed. The material penetrated consisted of a mixture of silt, sand, clay, fine and coarse gravel, hard pan and boulders, seemingly in pockets, without any uniformity of stratification, except for short stretches.

In places, one material over-lay another whereas 50 ft. away, the order was reversed. In places all the materials enumerated appeared in succession, while in other places only one or two of them appeared. The widest contrast shown was between a stretch of some twenty bents in which a layer of 6 to 10 ft. of hard pan on top was underlaid by stiff clay and a bottom layer of gravel, and a stretch of some fifteen bents in which from 20 to 30 ft. of soft silt lay directly on bedrock; no other materials appearing. The change from one extreme to the other occurred in a space of about 40 ft.

The specifications called for piles at least 12 in. in diameter 2 ft. below the butt, and 6 in. at the tip. But the contractor bought an odd lot of piles for the job, some of which came up to 15 or 16 in. in diameter, 2 ft. below the butt and 9 or 10 in. at the tip. About 500 of the piles in the worst part of the driving were shod with hollow malleable cast iron shoes which completely covered the point. Driving was done with 3,000-lb. drop hammers.

The writer, who was resident engineer for the owners on the job, maintained inspectors continuously on the drivers, who kept a complete record of each pile. A few facts were brought out which may be of value to engineers on similar work.

A number of piles were pulled after being driven, and notes made on the conditions of the tips. These tips tended to show that as a general rule, a yellow pine pile which is moving less than 1 in. under a 15-ft. hammer drop (3,000-lb. hammer) is probably not penetrating at all; but is brooming.

There were exceptions to this rule, particularly in the case of very large piles. But this seems to be a safe assumption for any pile much under 8 in. in diameter at the tip. When a pile has begun to broom before penetrating far it can usually be noticed by the "spring" when the hammer hits it. But after 10 or 12 ft. penetration in hard material, brooming is not so easily identified this way; the most experienced men being frequently at fault.

Another point which was brought out in many instances was that there is a minimum tendency to broom when the pile is sharpened to a blunt point. When a sharp or long point is made, the first stone encountered breaks it off, leaving a hollow into which all succeeding pebbles are forced like wedges. A pile without a point is also rapidly broomed by pebbles forced into its end.

The writer believes that the cast iron shoes which consist merely of a pyramidal shaped point fastened to the pile by straps, are of little value in penetrating gravel or hard pan, as they are easily turned over and broken off; often taking a part of the point of the pile with them and leaving it not only unprotected but in the shape best calculated to encourage brooming. This happened in two out of three cases where this type of shoe was tried on this job. The malleable cast iron hollow shoes did, however, prove effective in protecting the point of the piles. In one test case, a pile shod in this way, was pulled after having penetrated through 12 ft. of hard pan. The shoe was in place and in good condition; whereas an unshod pile had begun to broom after penetrating less than half the distance of the same material.

Few except the largest and straightest piles will stand being hit with a heavy hammer under a drop of more than 16 or 18 ft. without danger of breakage, unless they are in soft material, having considerable "give." If so hit, when in hard material even a fairly good pile will often break into two pieces, the upper piece telescoping down on the lower one. This is particularly the case in piles having large knots. A bent pile when hit too hard will often crack lengthwise through the center, sometimes for half or two-thirds of the length of the pile. Of course, its bearing power is so reduced when cracked in this way, that it is unsafe to use. Piles hit only 12 or 15 ft. blows, or even less, seemed to go down as rapidly, in point of times as those on which a 20 or 25 ft. blow was used; the more frequent blows making up for the less penetration per blow. And the piles were in better condition when so driven. In no case was a pile badly damaged under less than a 16-ft. blow. The tendency among the pile driver engineers was to strike the long blows. All of them had to be continually reminded throughout the job not to do this.

In this connection, it was brought out that the standard specifications for straightness, wherein a straight line from center to center of the ends of the pile shall be allowed to leave the circumference of the pile by 1/150 of its length, is too liberal for piles having a long unbraced span and which must be driven to carry heavy loads. In such cases, it would probably be better to limit the allowable divergence of the line from the circumference to ¼ of the diameter of the pile at the point of widest divergence. Piles accepted on the basis of the standard specifications sometimes prove to be unable to withstand these conditions of heavy driving and long span combined. And the writer believes from experience here that wherever driving is so hard as to make the use of shoes advisable, it would be well to use less liberal specifications for straightness.

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## AN AUTOMATIC CHUTE FROM CONCRETE MIXER TO BUCKET.

Contributed by Clyde B. Chace, 4126 Virginia Ave., Kansas City, Mo.

When concrete is hoisted by the familiar bucket and tower method it is necessary in many cases to have an intermediate chute between the mixer and bucket. While the bucket is loading this chute must extend over its edge, and when the bucket is hoisted it must be pulled up out of the way. A method of making this operation automatic is shown in the accompanying sketches. Figure 1 shows the method as used on the new Missouri Can Co. building in North Kansas City, Mo., last winter. Figure 2 shows a modification which the writer considers handier under some conditions.

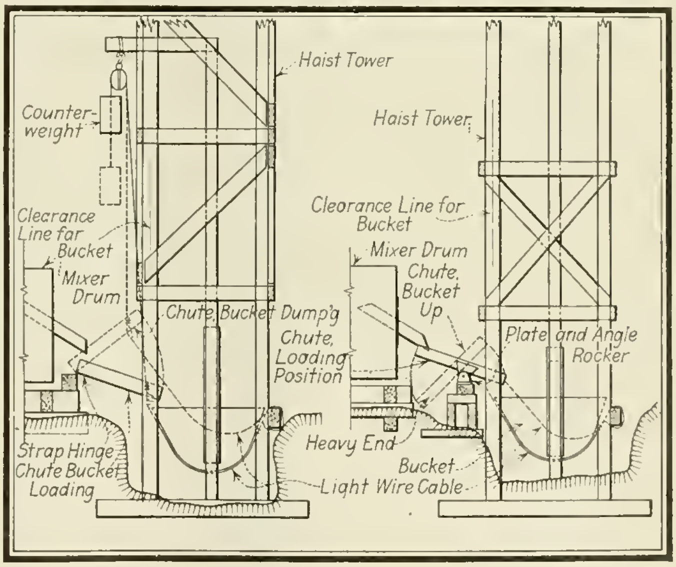


Fig. 2.

Fig. 1.

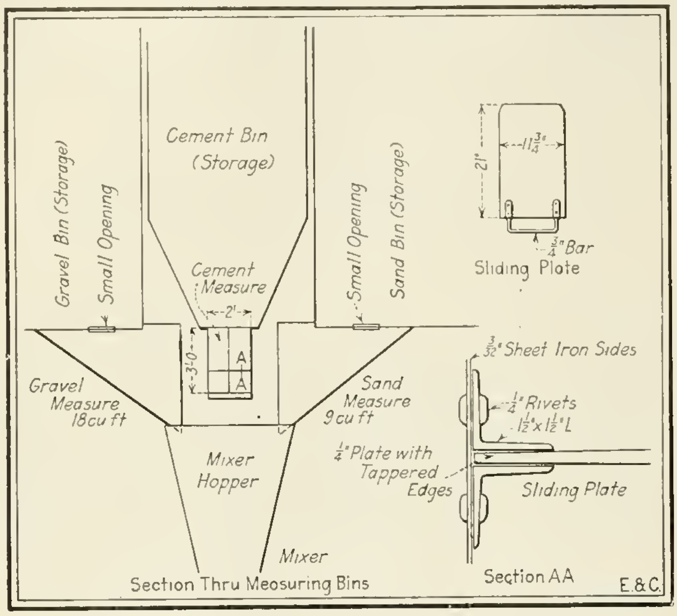
By the first method the chute is pivoted off center with the heavy end next to the mixer so that it normally stands clear of the bucket. In order to hold it in place to load the bucket a light wire cable is run under the bucket. On the side away from the mixer it is fastened to anything solid, while the other end is fastened to the end of the chute next to the bucket. The cable holds the chute in place while the bucket is in position to be loaded and releases it to fall back in the clear as soon as the weight of the bucket is lifted.

The method shown in Fig. 2 differs from the above only in that the chute is hinged at the end next to the mixer and is raised by a counterweight when the bucket is hoisting. This method has the advantage of requiring less room below the chute near the mixer. Its disadvantage is the bother of the counterweight.

## CEMENT MEASURING DEVICE FOR VARYING CONCRETE PROPORTIONS.

Contributed by W. D. Jones, Los Angeles Harbor Department, San Pedro, Cal.

In the construction of a concrete building at Los Angeles Harbor by the Merchants' Realty & Investment Co. of Los Angeles, for the city of Los Angeles, three different mixtures of concrete were specified. The nature of the work was such that it was necessary to change from one mix to another sometimes several times during the day's work and the following method used proved satisfactory and economical: The mixtures were 1:1:2, 1:1½:3 and 1:2:4, consisting of Portland cement, sand and gravel, respectively. Sand and gravel were loaded in storage bins either side of the mixer hopper, as shown in the sketch, a mixer having a rated capacity of 32 cu. ft. of loose material being used; the hopper, being stationary, was located a few feet below the bottoms of and between the two storage bins. Directly over the hopper and between the two bins for rock and gravel the cement bin was placed, with the measuring device attached to the bottom in such a way that the cement after being measured was released as wanted directly into the charging hopper of the mixer. The sand bin was provided with a measuring hopper holding 9 cu. ft. of loose material and the gravel bin with one holding 18 cu. ft., each located so that after the material was measured it could be released by a lever operating a sliding door and would flow into the mixer hopper. The cement measuring device was arranged so that by a simple manipulation of blades 4½ cu. ft., 6 cu. ft., or 9 cu. ft., as desired, of cement could be measured, the sand and rock bins being always held the same. Thus for a 1:1:2 mix the material measurements would be 9-9-18; for a 1:1½:3 mix the material measurements would be 6-9-18, and for a 1:2:4 mix the material measurements would be 4½-9-18. It will be noticed that the quantity of loose material in the 1:2:4 mix is about up to the capacity of the mixer and that the richer materials exceed the rated capacity. The specifications required that the sand and cement enter the mixer in advance of the stone, and due to the fact that the sand and cement were partially mixed before the gravel was admitted and that the gravel being admitted thus into a partially mixed material by the time the gravel was all in enough mixing had been done so that considerably more material could be added without overtaxing the capacity of the mixer. This proved out on the richer mixtures. Varying the measurement of cement was accomplished by having a box 24 by 18 by 36 in. high, as shown in the sketch, made of sheet iron 3/32 in. thick, with a partition vertically in the center, making two vertical compartments each 12 by 18 by 36 in. Slots were provided in each of these compartments for three sliding plates 11¾ by 21 in., as shown in the sketch, one being at the top, one at the bottom and 1-1 ft. up from the bottom. By using one whole compartment thus made 4½ cu. ft. of material was obtained; by using the upper 2 ft. of both compartments 6 cu. ft. was obtained, and by using all of both compartments 9 cu. ft. was obtained.



Measuring Device for Varying Concrete Proportions.

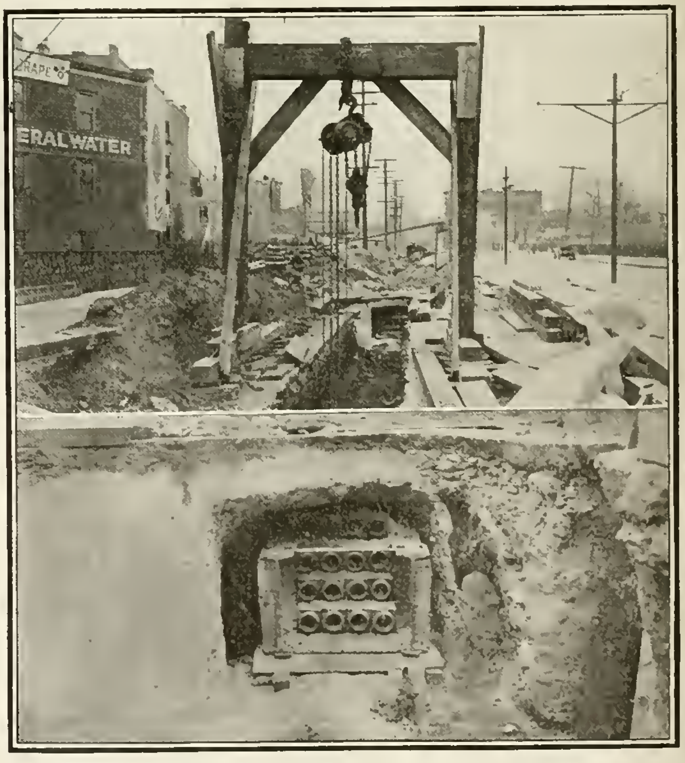
Some trouble was anticipated with the cement arching over the small opening, but by tapping on the sides with a hammer as the cement was being admitted this was avoided. In filling the measuring compartments, however, the air forced out as the cement entered carried considerable cement with it and made the plant operation unusually dusty. With this exception and some trouble in operating the sliding plates at first, due to their sticking in the grooves, the scheme was a success. Free movement of the plates was obtained by grinding the edges to a bevel on both sides, as shown in the sketch, section A-A. The location of the slots for the plates is designated by the figures 1, 2, 3, 4, 5, and 6, in the sketch, only four plates, however, being necessary to operate the device.

## CONSTRUCTION OF AN ELECTRICAL SUBWAY CROSSING ON A HIGHWAY BRIDGE.

Contributed by C. M. Hartley, Assistant Engineer, Empire City Subway Company, Ltd., New York City.

The following is a brief description of the method employed in the construction of a 16-duct electrical subway crossing on a highway bridge over the tracks of the New York Central Railroad Co., at St. Anne's Ave. and E. 149th St., Borough of the Bronx, New York City.

This bridge is a flat-arch concrete and steel structure, and rests on the retaining walls of the cut, which thus serve as abutments. The railway is a double track freight line. The base of rail is 20 ft. below the surface of the street. The clear span between the bridge-seats is 35 ft. 6 in. The bridge structure is formed of 30-in. girders, spaced 4 ft. 8 in. c. to c., and carrying reinforced concrete arches 12-in. in thickness at the crown.



Placing Electrical Subway Crossing Highway Bridge.

It was decided, after mature deliberation, to build the subway structure as a monolith, lower it into the trench at one end of the bridge, and then pull it into place between two of the bridge girders. It was thus possible to construct it without disturbing the arches or the roadway.

Creosoted wood ducts were selected as the material of which to build the subway. The design embodied two 18-in., 55-ft. I beams, 41 ft. 6 in. long, and spaced 24½ in. c. to c., between which the creosoted wood ducts were carried. They were laid, four wide and four high, on a 4-in. reinforced concrete base. The space between the ducts and the beams was then filled in with concrete, and the whole encased in a reinforced concrete envelope. The beams were braced and tied together every 10 ft. with ¾-in. tie-rods. The maximum weight of this subway, with all the ducts occupied, will be 534 lb. per lineal ft., or a total weight of approximately 10 tons.

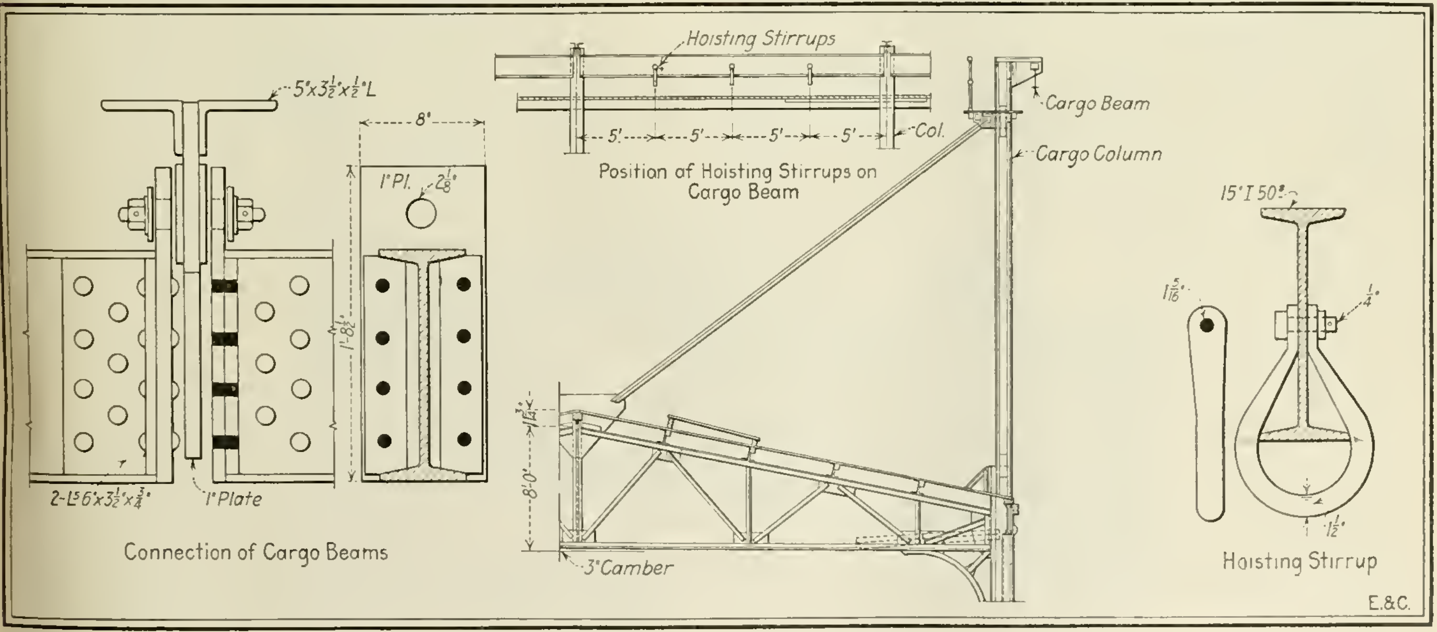
This monolithic structure, which was built and supported on cross-pieces over the trench, after setting for one week, was lowered into the trench, one end at a time, by means of a 5-ton triplex chain-hoist carried by a "horse" built over the trench.

Holes were then cut through the concrete back-walls of the bridge, and a temporary falsework erected underneath, on which to roll the subway across. A hand-winch was placed alongside the trench, and, with a block and tackle secured to a "dead-man" in the trench, the structure was pulled across until the ends rested on the bridge seats. One-half hour was consumed in this operation. Speed was essential, though the work was performed on Sunday, when there is practically no traffic on this branch.

It will be noted that the subway is self-supporting, and entirely independent of the bridge structure proper. The accompanying photographs show one end of the subway, in place under the bridge, and the chain-hoist and "horse" used in lowering it into the trench.

## SWINGING CARGO HOIST BEAM FOR NEW YORK HARBOR PIER SHED.

In the new New York City steel pier sheds under contract, an improved cargo hoist beam of the design illustrated is being used. The sheds are double deck and have 20-ft. longitudinal bays, and the outside wall column at each bay extends high above the shed roof to carry the cargo hoist beams. In the new piers the cargo hoist beam is a rolled I-beam having a hinged connection to the column top as shown by the drawings. As will be seen, this hinged connection permits the bottom of the beam to swing out when the pull is diagonal and thus keep its web always parallel to the pull of the load. Formerly with rigid connections a built-up plate girder cargo hoist beam was necessary to resist the eccentric load. Referring to the drawings Chief Engineer Staniford writes: This is the same arrangement which we are now using in the contract for the double deck pier at W. 57th St. The W. 56th and W. 57th St. contracts are now being fabricated under the general contract of the Pennsylvania Steel Co. The contract for the W. 55th St. pier, drawing for which is shown, has been let to Snare & Triest Co. All of these detail plans were gotten up by the Engineering Bureau of the Department of Docks & Ferries under C. W. Staniford, Chief Engineer; R. A. C. Smith, Commissioner, and R. C. Harrison, Deputy Commissioner.



Cargo Hoist Beam, New York Pier Sheds.

## A SUMMARY OF TWENTY THOUSAND TESTS OF CONCRETE.

A notable report on the strength and other properties of concrete as affected by materials and methods of preparation has been issued by the Bureau of Standards. This report is written by Messrs. R. J. Wig, G. M. Williams and E. R. Gates, experts of the Bureau and presents the results of about 20,000 tests. Compressive and tensile tests were made upon mortars at different ages, including about 240 different sands and stone screenings and compressive tests were made on concretes composed of 60 aggregates including limestones, gravels, granites, cinders, and trap rock, as well as tests of the physical properties of the sands, stone screenings, and coarse aggregates.

In order that the effect of each variable on the compressive strength might be determined, the consistency of the mixture, the conditions of storage of the concrete, and the workmanship in fabrication were changed so that comparative results might be obtained.

The weight per cubic foot of concrete, as determined from the weight of the test pieces, was recorded in all cases before making the compression tests, and compressometer readings were taken in most cases during the testing of the cylinders, from which the yield point and initial modulus of elasticity were determined. A series of comparative density and strength tests were made in a number of cases which show the effect on compressive strength of varying the relative proportions of the same fine and coarse aggregates.

### Conclusions.

(1) No standard of compressive strength can be assumed or guaranteed for concrete of any particular proportions made with any aggregate unless all the factors entering into its fabrication are controlled.

(2) A concrete having a desired compressive strength is not necessarily guaranteed by a specification requiring only the use of certain types of materials in stated pro-

portions. Only a fractional part of the desired strength may be obtained unless other factors are controlled.

(3) The compressive strength of a concrete is just as much dependent upon other factors, such as careful workmanship and the use of the proper quantity of water in mixing the concrete, as it is upon the use of the proper quantity of cement.

(4) The compressive strength of concrete may be reduced by the use of excess of water in mixing to a fractional part of that which it should attain with the same materials. To much emphasis can not be placed upon the injurious effect of the use of excessive quantities of water in mixing concrete.

(5) The compressive strength of concrete may be greatly reduced if, after fabrication, it is exposed to the sun and wind or in any relatively dry atmosphere in which it loses its moisture rapidly, even though suitable materials were used and proper methods of fabrication employed.

(6) The relative compressive strength of concretes to be obtained from any given materials can be determined only by an actual test of those materials combined in a concrete.

(7) Contrary to general practice and opinion the relative value of several fine aggregates to be used in concrete can not be determined by testing them in mortar mixtures. They must be tested in the combined state with the coarse aggregate.

(8) Contrary to general practice and opinion the relative value of several coarse aggregates to be used in concrete can not be determined by testing them with a given sand in one arbitrarily selected proportion. They should be tested in such combination with the fine aggregate as will give maximum density, assuming the same ratio of cement to total combined aggregate in all cases.

(9) No type of aggregate such as granite, gravel, or limestone can be said to be generally superior to all other types. There are good and poor aggregates of each type.

(10) By proper attention to methods of fabrication and curing, aggregates which appear inferior and may be available at the site of the work may give as high compressive strength in concrete as the best selected materials brought from a distance, when the latter are carelessly or improperly used.

(11) Density is a good measure of the relative compressive strength of several different mixtures of the same aggregates with the same proportion of cement to total aggregate. The mixture having the highest density need not necessarily have the maximum strength, but it will have a relatively high strength.

(12) Two concretes having the same density but composed of different aggregates may have widely different compressive strength.

(13) There is no definite relation between the gradation of the aggregates and the compressive strength of the concrete which is applicable to any considerable number of different aggregates.

(14) The gradation curve for maximum compressive strength, which is usually the same as for the maximum density, differs for each aggregate.

(15) With the relative volumes of fine and coarse aggregate fixed, the compressive strength of a concrete increases directly, but not in a proportionate ratio as the cement content. An increase in the ratio of cement to total fine and coarse aggregates when the relative proportions of the latter are not fixed does not necessarily result in an increase in strength, but may give even a lower strength.

(16) The compressive strength of concrete composed of given materials, combined in definite proportions and fabricated and exposed under given conditions can be determined only by testing the concrete actually prepared and treated in the prescribed manner.

(17) The results included in this paper would indicate that the compressive strength of most concretes, as commercially made, can be increased 25 to 100 per cent or more by employing rigid inspection which will insure proper methods of fabrication of the materials.

## METHODS AND COST OF MAKING AND SINKING PRE-MOULDED CONCRETE PILES.

Contributed by Geo K. Leonard, Chief Draftsman, State Engineer's Office, Lincoln, Nebr.

The plans for the construction of the Lexington, Neb., State Aid Bridge, across the Platte River, called for the placing of three concrete piles 12 in. square and 45 ft. long under each of 26 piers. The bed of the Platte River, throughout its entire length, is composed of successive layers of sand and gravel, varying in size from quicksand to 5-in. stones. At this particular point, clay was struck at a depth of 40 ft. below low water, and the piles were to penetrate this 3 ft., the remaining 2 ft. projecting into the pier. The piles were reinforced, as shown in Fig. 1.

Two moulding floors 24 by 48 ft. were made and the piles cast in lots of 16, by moving the side forms from one floor to the other. Following is the material bill for the forms:

| | Ft. B. M. |
|---|---|
| Sleepers, 26-4"x4"-24' | 832 |
| Two floors, 18-2"x12"-48' | 4,608 |
| Sides, 32-2"x12"-48' | 3,072 |
| Top braces, 14-4"x1"-24' | 448 |
| Miscellaneous for wedges, etc. | 260 |
| Total | 9,220 |

56-¾"x2'-6" bolts.

COST OF MATERIAL AND LABOR FOR 78 PILES.

| | |
|---|---|
| Material: | |
| Cement, 751 sacks @ $0.432 | $ 326.51 |
| Rods, 52,645 lb. @ $0.0275 | 1,084.23 |
| Mesh, 12,166 sq. ft. @ $0.0314 | 382.01 |
| Gravel, 118½ cu. yd. @ $0.75 | 88.88 |
| Lumber, 9,220 ft. B. M. @ $26 per M | 239.72 |
| Bolts, 56 @ $0.15 | 8.40 |
| Total | $2,129.75 |
| Material, cost per pile | 27.31 |
| Material, cost per lin. ft. | .607 |
| Labor: | |
| Making, placing and removing forms | $ 148.60 |
| Placing reinforcing | 353.50 |
| Mixing and placing concrete | 97.96 |
| Total | $ 600.06 |
| Labor, cost per mile | 7.69 |
| Labor, cost per lin. ft. | .170 |

Ordinarily a concrete pile will sink in the Platte River of its own weight, if properly jetted. This was tried, but at a depth of 40 ft. a coarse layer of gravel was encountered, which carried off the water as fast as it could be pumped, and the piles would sink no further.

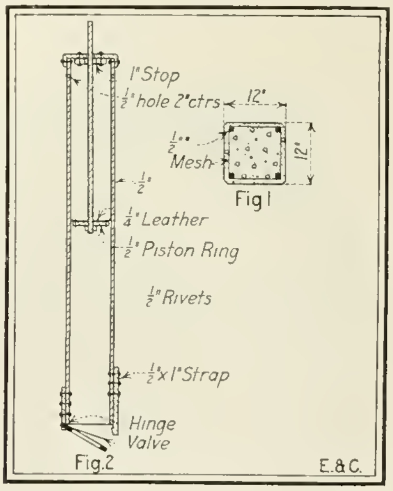


Fig. 1. Section of Pile. Fig. 2, Sand Bucket.

Not deeming it advisable to hammer on the piles, 3 ft. was cut off of each one, and the following method used in sinking them so that they would rest on the clay:

By means of a specially designed sand bucket, which will be described later, a 22-ft. length of 1¼-in. steel casing, 24 in. in diameter, was sunk until the top was about 2 ft. above the water. Into this was set a 40-ft. length of casing 20 in. in diameter, which was sunk until it rested on clay. The pile was then set into the open well, and the two sections of casing pulled. The sand running in around the pile held it as firmly as if it had been driven. A steam hoist and derrick handled the casings and piles.

The bucket, which was used in excavating and sinking the casings, is shown in Fig. 2, and is described as follows: A piece of heavy steel pipe 8 in. in diameter and 6 ft. long was fitted with a hinged bottom, containing an ordinary valve opening inward. The bottom was held shut by means of a dog, which could be tripped with a hammer when the bucket was full of sand. Riveted to the top of the bucket was a steel head through the center of which the piston rod slipped. The piston was an ordinary pump piston, with leather attached. In operation, the bucket, with the bottom closed, is dropped to the bottom of the casing by means of a gasoline hoist, the hoisting line being fastened to a ring in the upper end of the piston rod. As the piston is pulled to the top, the sand is sucked in at the bottom and the bucket settles. When the piston is at the upper end of the bucket it strikes the top and bucket and all is hoisted to the top of the casing and dumped. As the sand is taken from the casing it settles, due to its own weight, and to a number of sand bags on a platform, hanging from the top of the casing. (See photograph.) In this way, with a gang of two men at 30 ct., and one man at 20 ct. per hour, working ten hours per day, one pile could be placed per day.

The cost of sinking the piling for the job, excluding superintendence, cost of equipment, repairs, etc., is:

| | |
|---|---|
| Labor | $634.55 |
| Coal, 5 tons | 31.50 |
| Gas, 210 gal | 23.10 |
| Total | $689.15 |
| Sinking cost per pile | 8.84 |
| Sinking cost per lin. ft. | .221 |
| Total cost per pile in place | 43.84 |
| Total cost per lin. ft. in place | .998 |

The contractors for the work were Wood, Bancroft & Doty, David City, Neb.

## A CONCRETE MIXING PLANT 180 FT. ABOVE CHICAGO.

(Contributed.)

A complete concrete mixing plant, mounted on the roof of a skyscraper, turning out large quantities of concrete for an extensive addition to the building, is the latest contribution of Chicago in modern methods of building construction.

The large department store of Rothschild & Co. desired to increase their storage space by constructing an additional story at one end of the present structure. The building is nearly a block long, extends to an alley in the center of the square and is 10 high stories above the street level with three basements below. This building is of modern steel frame construction, built several years ago, and was designed to carry additional stories when the growth of the business should require them.

It was desired to construct an additional story at the south end of the building extending 176 ft. on State St. and 144 ft. on Van Buren St., and a contract for this work was recently let to Clark-Bisbee Co., 2300, 175 W. Jackson Blvd., Chicago. The street walls of the present building extend a considerable distance above the roof so that it was only necessary to construct a new roof and floor with the required columns, beams and girders. The new construction is entirely of reinforced concrete and the contractors decided that this could be handled most successfully by placing the mixing plant on the present roof of the building.

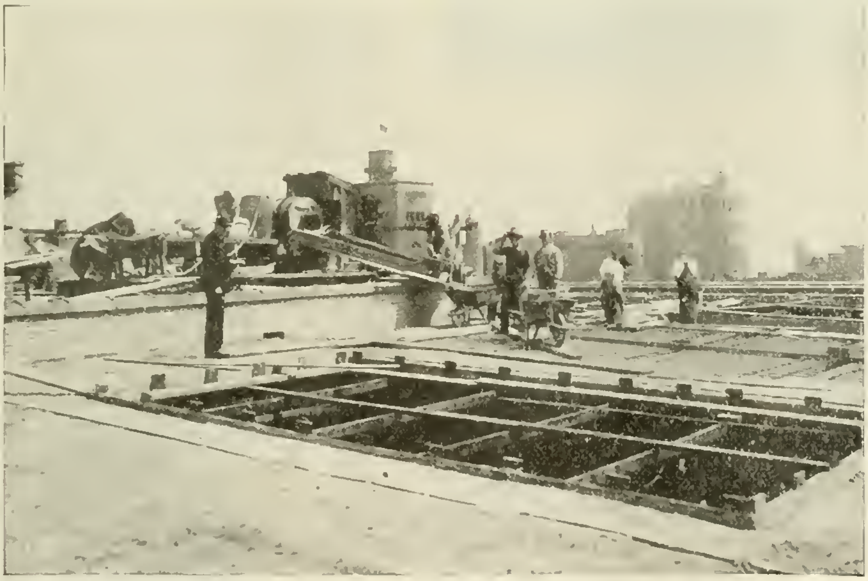
The equipment of the building, in addition to an extensive passenger elevator service, includes two large high-speed freight elevators which travel from the third basement to the tenth floor, one of which is of 10 tons capacity. In the third basement are several elevator hoppers connected by chutes with the surface in the rear alley and provided with discharge gates designed to provide coal storage for the furnaces and which discharge the coal into a traveling bucket as required.

It was decided to use several of these hoppers for handling the sand and stone in the new construction work. Material was delivered in 6-ton auto trucks and dumped down the chutes into the hoppers from which it was gated into wheelbarrows. The large elevator carried nine wheelbarrows and the smaller one five to the tenth floor at each load. An inclined runway was built from the tenth floor to the roof and all material used in the concrete and the new construction work is transported from the tenth floor up this inclined runway.

For mixing the concrete, on account of its light weight and great portability, the contractors used a motor-driven 8 cu. ft. capacity low charging mixer built by the Standard Scale & Supply Co., Chicago, Ill. The mixer was taken up the large elevator to the tenth floor and then transported up the material runway to the roof, 180 ft. above the street level. The accompanying illustration shows the discharge side of the mixer in operation.

In this work the columns, girders, beams and roof were constructed first, after which the old roof underneath was removed and replaced with a reinforced concrete floor. There were required 95 concrete beams, 22 concrete girders, 14 concrete columns and in the construction work was used over 13 tons of reinforcing steel rods, many of them 28 ft. long, and about 40,000 ft. B. M. of lumber for the forms. The concrete is a standard 1:2:4 mix, the coarser aggregate being crushed limestone screened to a $\frac{1}{2}$-in. mesh.

Due to the excellent facilities for handling the material this work has proceeded very rapidly and with apparently little more difficulty in handling the concrete than when mixed at ground level.

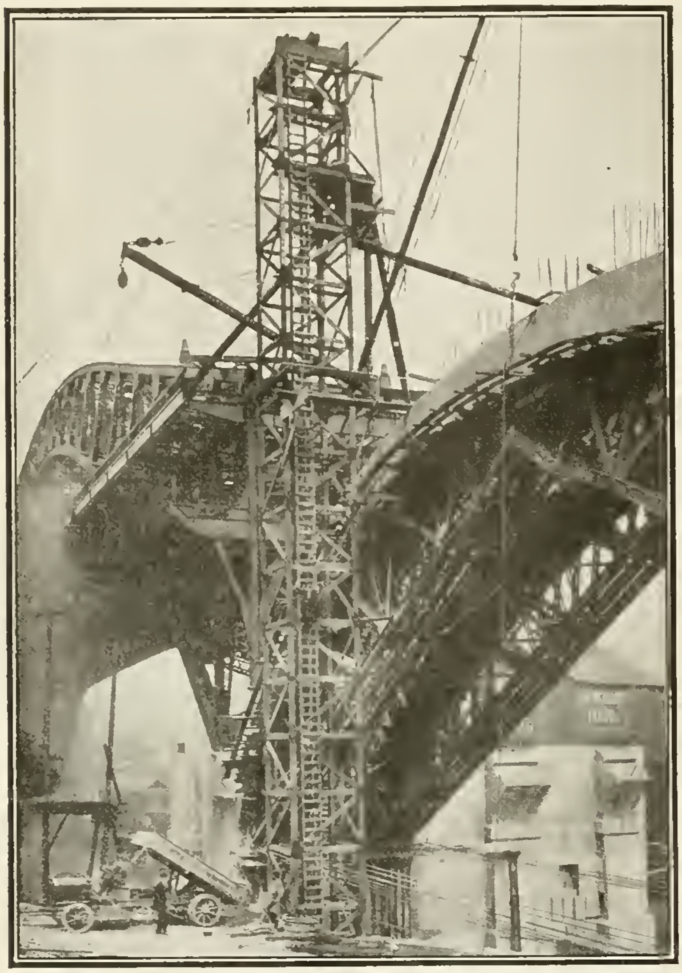


Mixing Concrete 180 ft. Above Chicago.

## CONVEYING CONCRETE BY MOTOR TRUCK.

Contributed by Harold E. Kitchener, Superintendent of Construction, Detroit-Superior High Level Bridge, Cleveland, O.

The concrete for the west end of the Detroit-Superior High Level Bridge is being conveyed from the main mixing plant on the east side of the Cuyahoga River, a distance of a quarter of a mile, in the bodies of motor trucks. Both White and Kelly-Springfield trucks of five ton capacity are used. At the mixing plant, a picture of which was published in Engineering and Contracting on June 7, 1915, the two-yard concrete hopper is high enough for the trucks to drive under. It requires 20 seconds to load the trucks with two yards of concrete from the hopper. The running time from the mixer to the hoisting tower is about 2½ minutes. Even in this short time the stone in the concrete, due to the vibration, has a tendency to settle to the bottom of the truck and it requires from 40 to 50 seconds for two men to loosen it. The receiving hopper at the tower, with a capacity of five yards, serves as a remixer and produces a concrete satisfactory for chuting.



Hauling Concrete by Motor Truck.

The average cost of hauling, considering the trucks on a rental basis of $2.50 per hour each, has been $0.19 per cubic yard of concrete. On concreting an arch rib of 440 cu. yd. an average speed of 40 cu. yd. per hour was maintained, including delays due to the swinging of the drawbridge over the river. Three trucks were used.

Previous to hauling the mixed concrete, the concrete materials were hauled from the east side bunkers to a separate mixing plant on the west side. The hauling of the materials cost 35 per cent more than hauling the mixed concrete and involved the extra expense of maintaining the second plant.

The Detroit-Superior High Level Bridge is now 75 per cent complete. A contract for subway approaches to cost $850,000 is about to be let.

## COSTS OF HOSPITAL BUILDINGS.

Costs of hospital buildings are given by O. H. Bartine in a paper read before the American Hospital Association. The following data are summarized from detailed tabulations. For 22 buildings the building and equipment costs per cubic foot were as follows:

| Item. | Per cu. ft. Ct. |
|---|---|
| Total building | 38.2 |
| Heating and ventilating | 3.3 |
| Electric system | 0.9 |
| Electric fixtures | 0.3 |
| Plumbing | 2.9 |
| Refrigeration | 1.2 |
| Vacuum cleaner system | 0.2 |
| Elevators | 0.7 |
| Kitchen equipment | 0.4 |
| Power plant | 4.7 |

The segregated building costs for 13 hospitals were per cubic foot as follows:

| Item. | Per cu. ft. Ct. |
|---|---|
| Excavation | 2.6 |
| Masonry | 12.4 |
| Structural steel | 4.5 |
| Carpentry | 2.8 |
| Roofing | 1.0 |
| Glass and glazing | 3.6 |
| Skylights and sheet metal | 1.1 |
| Painting | 0.6 |
| Lathing and plastering | 1.23 |
| Composition flooring | 0.8 |
| Tiles, mosaics and marbles | 2.11 |
| Hardware | 0.5 |
| Cast iron | 2.2 |
| Total | 43.2 |

In determining cubical contents the author states: "Measurements should be taken from the basement or sub-basement (lowest) floor level to the mean of the outside of the roof, and from outside to outside of walls. In other words, the cubic feet of air displaced by the exterior dimensions of the building should be considered, eliminating approaches, balustrades and other projections not enclosing space."

## METHOD AND COST OF TREATING SHEET PILES EXPOSED TO SEA WATER WITH AVENARIUS CARBOLINEUM.

Contributed by W. D. Jones, Assistant Engineer, Harbor Department, Los Angeles, Cal.

In the construction of a timber wharf 50 ft. wide and 1,600 ft. long resting on creosoted piles, at Los Angeles Harbor, a bulkhead was specified as follows:

Lumber.—All lumber for sheet piles must be 4x12-in. No. 1 merchantable Oregon pine (Douglas fir), sound, free from large, loose or rotten knots, knot holes, splits, shakes, wain, rot, pitch seams open on both sides of the piece, worm holes or other defects which materially impair the strength of the piece. Each piece shall have a groove 1 in. wide and 1 in. deep cut in each edge. In one of the grooves a spline 1x1¾ in. shall be spiked to form a tongue.

Apparatus for Treating Sheet Piles.

Treatment.—All sheeting shall be dipped such that the upper 15 ft. be immersed for at least twenty minutes in Avenarius Carbolineum, which shall be kept at a temperature of 212 to 220 degrees F. during the dipping. The heating to be accompilshed by steam coils. (This was not done.) Manufacturers estimate that the amount of Carbolineum necessary for this treatment will be 1½ lb. per cubic foot of lumber treated. The Carbolineum must be brought to the dipping station in the original containers and must give the following analysis and qualities:

| | |
|---|---|
| Specific gravity at 17 deg. C. | 1.128 |
| Viscosity (water-1) | 10 |
| Flashing point, deg. C. | 145 |
| Burning point, deg. C. | 210 |
| Distillate below 235 deg. C., per cent | 0.44 |
| Distillate between 235 deg. C. and 300 deg. C., per cent | 7.50 |
| Residue above 300 deg. C. (clear red brown), per cent | 92.01 |
| Mineral matter (ash), per cent | 0.10 |
| Napthalene (210-230 deg. C) | Trace |
| Phenols (carbolic acid according to Seubert) | No separation |

The treatment was accomplished by means of the plant shown in the illustration, an old boiler shell with upper end open being set in a brick oven in such a manner as to permit fire reaching the bottom and considerably up the sides. An arrangement was made on the side of the boiler for taking temperatures, which were kept reasonably well within the prescribed limits. An A frame arrangement, as shown, was erected over the tank thus made and a single-drum hoisting engine used to hoist the lumber into the tube to be treated. A sufficient depth of oil was maintained to give the desired length of treatment to each piece, the pieces being lowered into the treating basin end first.

The following cost includes picking the lumber up from storage piles near the treating plant, treating it, and piling it nearby after treatment.

Treated portion of pieces, ft. B. M. .......... 144,222
Treated portion of pieces, sq. ft. surface area .......... 107,984
Cost of treatment—Labor, $1,227.57; equipment service, $66.65; material, $1,136.20.
Cost of treatment per 100 sq. ft., $1.14; equipment service, $0.06; material, $1 05.
Cost of treatment per 1,000 ft. B. M.—Labor, $8.51; equipment service, $0.46; material, $7.88.

A total of 1,196 gal. of carbolineum was used. This amounts to approximately 11,300 lb., being slightly less than 1 lb. per cubic foot of lumber treated. The cost of this amount of material was, as given above, $1,136.20. The cost of the lumber is not given here. Some difficulty was experienced in keeping the shorter lengths of lumber immersed, due to its floating up in the liquid. The Russell-Greene-Foele Co. of Los Angeles was the contractor for this work.

## WEB STRENGTH TESTS OF I-BEAMS AND PLATE GIRDERS.*

The tests reported in this bulletin were made to study the web strains in I-beams and girders so designed that the primary failure would be a web failure. The best data obtained were used in conjunction with a mathematical analysis made to determine the importance of the diagonal strains and the methods of failure of girders. The results obtained are summarized as follows:

(1) The measured strains in various parts of the six I-beams and two built-up girders agree closely with the strains as computed by the ordinary elastic theory if due allowance is made for the lateral strain (Poisson's ratio effect).

(2) The maximum shearing stress in an I-beam or a built-up girder is in some cases the shearing stress at the neutral axis, and is in other cases the diagonal shearing stress caused by the combined stresses in the web at its junction with the flange. However, the two are usually, nearly equal, and, in general the shearing stress at the neutral axis may be used in designing girders.

(3) A common approximate method of computing the shearing stress in the web of a girder is to divide the total shear upon a transverse section by the area of the cross-section of the web. If the value given by this method is more than 80 per cent of the allowable stress in shear for the material, a check computation for shearing stress should be made, using the more precise formula.

(4) The yield point (not the ultimate strength) of the material in shear should be regarded as the ultimate shearing stress which can be developed in the webs of girders. The ratio of the yield point in shear to the yield point in tension for structural steel is about 0.6, and the ratio of the allowable shearing stress to the allowable tensile or compressive stress may be taken at the same value.

(5) The maximum tensile or compressive strain in an I-beam or built-up girder is in some cases the longitudinal strain in the extreme fibers of the flange, and is in other cases the diagonal strain in the web adjacent to the flange. The diagonal strain may be enough greater than the longitudinal strain to make it desirable to consider the former in the design of a girder. The value of $E_\epsilon$ corresponding to the maximum strain should not in any case exceed in magnitude the safe working stress of the material in tension. (The safe stress in tension for structural steel is usually taken at 16,000 lb. per square inch.)

(6) In the case of girders having no stiffeners except at points at which concentrated forces are applied, the web is capable of developing the lowest of the following critical values: (1) the yield-point strength of the material of the web in shear; or (2) the compressive strength of the web as computed by Euler's formula, considering a 45-degree strip as a fixed-ended column subjected to a compressive stress equal to the transverse shearing stress at the neutral axis; or (3) a diagonal strain equal to the strain at the yield point of the material in tension.

(7) It would seem that the ability to resist buckling of thin webs without intermediate stiffeners had been underestimated.

(8) Stiffeners at supports and under concentrated loads are very necessary. These should be well fitted to the flanges.

(9) The local compressive stress in the web of a girder when no stiffeners are used at points at which concentrated forces are applied may be computed with a fair degree of accuracy by the use of Hudson's formula. Even if this stress is low, the use of stiffeners at points at which concentrated forces are applied diminishes the danger of lateral bending of the beam at the junction of the web and the flange.

(10) The deflection of the girders as measured and as computed by the ordinary elastic theory agrees closely when the deflection due to shear is considered. For short-span beams the deflection due to shear may be as much as 20 per cent of the total.

## BUILDING CONCRETE FORMS FOR SMALL BRIDGE ABUTMENTS AND PIERS.

Contributed by J. C. Worrell, Excelsior, Minn.

It is the usual custom to wait until the excavation is completed and the engineer has staked out the abutment or pier before the forms for concrete are started. On small abutments and piers nearly all forms can be built before or while the excavating is being done, and they can be built better and much cheaper than where built in place. A carpenter does not like to help do the excavating, especially if it is wet, and if he does not build the forms before the excavation is completed, he is practically killing time.

Pier forms can be made of four sections, two sides and two ends. Abutments with wings will require two sections for the main walls, two side sections for each wing, and two end sections, making eight sections in all. It is usually a wet and dirty place to work when building forms in place, but a dry place can always be found to build the forms in sections before they are put in place. Forms built in this way can be quickly fitted together; no plate need be used at the bottom, no helpers are needed to carry the lumber down a steep bank a stick at a time, and the carpenter does not need to climb out of the hole every time he wants to saw a board.

It saves work for the engineer, too, because in laying out an abutment, he needs only to give the face of the main wall of the abutment, the center line of the track on the front wall section of forms, and the angle which the front wall of the wings makes with the front face of the main wall. If the form sections are built correctly, they will fit and the dimensions of the abutment will be correct. In laying out the pier, the center line of the pier at right angles to the track and the center line parallel to the center of track will be given.

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*Extract from Bulletin 86, Engineering Experiment Station, University of Illinois, by H. F. Moore and W. M. Wilson.

The wiring and bracing will need to be done in place. The holes for the wires should be bored with a snall bit One man on each side of the forms and one inside will put in wires almost as fast as one man will cut them. I think that it is safe to say that forms can be constructed in the above manner for half what it costs by the usual method.

Many building contractors are building all of the forms they can at the shop and sending them to the job to be set up in place. They even hire men to design forms so that they may be built and erected in the cheapest possible way. There is no reason why railways who do their own concrete work can not furnish concrete form plans for small bridges and culverts and save on the price of the foundations. It will pay bridge contractors to have a man design concrete forms so that the carpenter can make the forms up in sections ready to put together as soon as the excavation is completed. It will give carpenters plenty to do while the excavating is going on and will save delay for the concrete crew, because the concrete crew can be used to advantage in placing the sections and wiring and bracing the forms ready for concrete.

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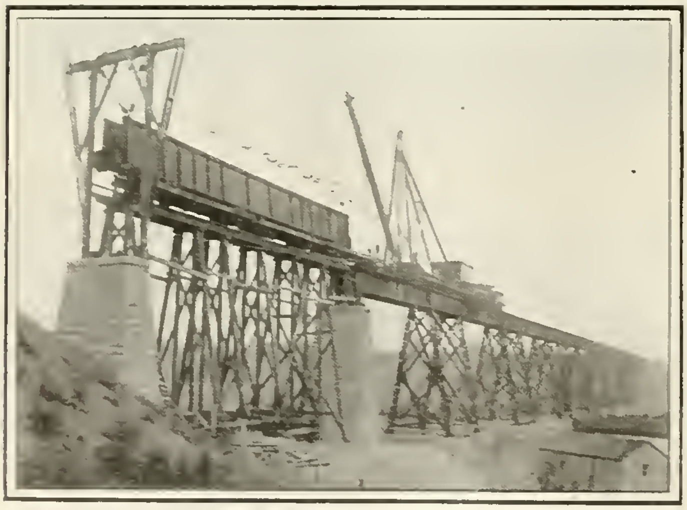
## HANDLING LONG GIRDERS.

Contributed by J. C. Worrell, Excelsior, Minn.

In 1906 the Kelly-Atkinson Co. erected a 100-ft. deck girder span for the C. & N. W. Ry. at Manitowoc, Wis. False work bents were used to carry the flat cars on which the girders were loaded, and the girders were unloaded on the masonry piers just outside of the falsework. The contractors had a derrick car with a boom which would reach to the center of the girder, but the boom would not carry the load of one girder which weighed about 33 tons, so a gallows frame was constructed to handle one end and the boom of the derrick car took care of the other. There were enough blocks on the gallows frame so that the niggerhead on the derrick car was used to raise this end, the other end was handled in the usual manner with the boom of the derrick car.



Placing 100-ft. Girder.

There was plenty of power to raise each end, but the girder was so limber that it looked as if it would double up before it was landed on the masonry. Before the second girder was raised, I suggested to the foreman that he take hold of the girder with the boom about 20 ft. from that end, but to lift the end with the gallows frame the same as before. The boom could handle two-thirds of the weight of the girder with no danger, so he decided to do it the way I had suggested. The result was that the girder remained straight while it was being lifted and landed on the masonry piers.

Long girders are often handled with two derrick cars, and there are derrick cars which can handle a 100-ft. girder alone, but this one could not, and the combination of the gallows frame and the derrick car seemed to be the best way to handle the girder in this case. In the above case, the rigging was probably no different than has been used many times, but the important thing was in taking hold of the girder in the right place in order to prevent buckling.

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## ECONOMICAL METHOD OF MAKING CONCRETE SLABS FOR BRIDGES.

Contributed by J. C. Worrell, Excelsior, Minn.

As superintendent for the Widell Company of Mankato, Minn., in 1913, I had occasion to save some money on some concrete slabs which we were making for bridges on the Great Northern Ry. in Montana. The specifications said that the slabs were to be made on the bridge site, but the ground was very broken and it would have required a great deal of timber and work to build supports strong enough to hold these slabs. The slabs were 15 ft. long, 6 ft. wide and about 3 ft. thick, and they weighed about 15 tons.

I explained the situation to the resident engineer and got permission to build them along a siding about a mile from the bridge site. The forms were then made on level ground where it required a minimum of supports, and they were built close enough to the track so that the wrecker could easily reach the finished slabs and load them on flat cars. The crew finished a culvert job a short distance from this one about the same time that the carpenters finished the forms for the six slabs. I had them load the mixer on a flat car and it was placed on the siding near the forms for the slabs. The train crew placed the gravel required to mix the concrete on each end of the flat car with the mixer. The cement was loaded on the flat car with the mixer, and when the end doors of the gondolas were let down, it made a good runway for wheeling the gravel to the mixer. When the switching was done, we dismissed the train crew and moved the cars with pinch bars from one form to the other. The concrete was dumped directly from the mixer into the forms.

We saved unloading and loading up the mixer, and one handling of the gravel. No gravel was wasted, because no more was unloaded than was used; and the loaded cars were not held any longer than usual. Taking everything into consideration, it was a saving to both the contractor and the railway.

## RAISING THREE SINGLE TRACK, 240-FT., PIN CONNECTED TRUSS BRIDGE SPANS 6 FT. UNDER TRAFFIC.

A successful task of bridge raising, using very simple methods, is illustrated by the accompanying engravings. The bridge consists of three single track, 240-ft., pin connected truss spans on masonry piers as shown by Fig. 1. It crosses the Kiskiminetas River on the Allegheny division of the Pennsylvania R. R. and carries a heavy traffic. In connection with a general elevation of the grade it was required to raise the bridge 7 ft. at one end and 5½ ft. at the other end, and the means devised for doing this are illustrated by the drawings of Fig. 2.

Six jacking beams constructed as shown by drawings I, II and III, were built; these were shifted between abutments and piers as required. Considering one end of a span, two jacking beams were set up, one straddling each truss end. The eye-bar slings were slipped over the pin ends which projected outside the chords and had their regular nuts replaced by pilot nuts. The jacks were then operated, raising the truss ends, blocking being placed in a manner to be described later, as the raising progressed. Generally the procedure was as follows: Beginning at one abutment the span end was lifted 16 in. and blocked; then four jacking beams were taken to the adjacent pier and both span ends were raised 16 in. and

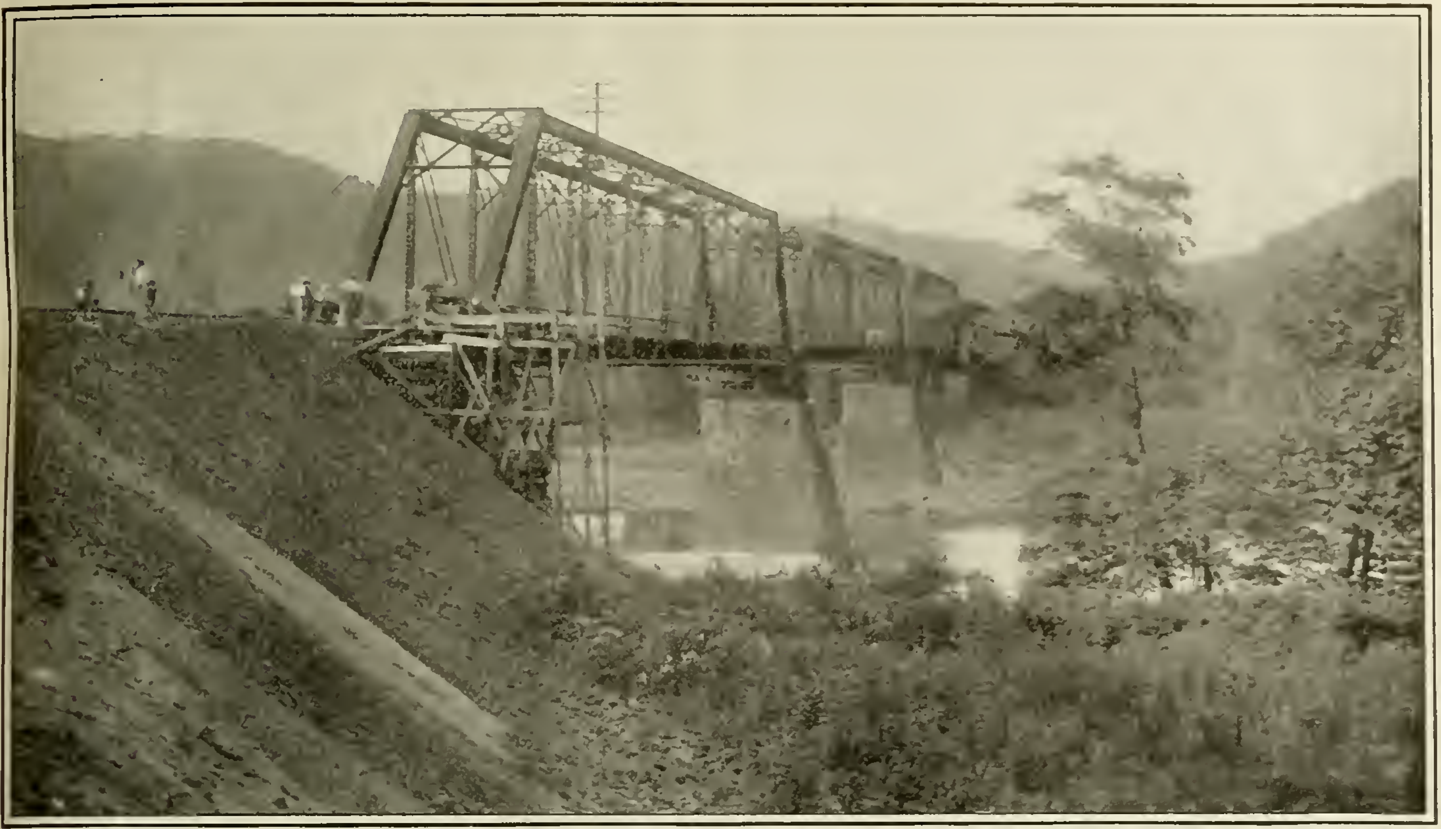

Fig. 1. Three Span Bridge Raised Six Feet.

blocked; then the four jacking beams were taken to the second pier and both span ends were raised and blocked; finally the jacking beams used on the first abutment were carried to the other abutment and the span end was raised and blocked. The initial raise of 16 in. being completed for all spans, the gang began a second raise by working back toward the original starting point. These procedures were repeated until the full height of raise at each span end was attained.

The method of blocking was an important feature in the success of the operation. Referring to drawing IV, Fig. 2, as the span was raised wedges were driven under the shoes and kept tight. When the shoes were high enough to permit the wedges were replaced by 3x12-in. x 4-ft. planks laid three under each shoe across pier as indicated at A. In the same way the stringer girders were blocked up as indicated at B. Wedging then proceeded on the plank blocking until raising had proceeded sufficiently to permit insertion of a second set of planks on top of the first set. Thus the raising and blocking proceeded until the blocking was 16 in. high; then one width of plank blocking was removed and replaced by a 12x12-in. x 4-ft. timber block with plank blocks on top. In the same way as second, third and other rows of plank blocking were removed one at a time and replaced by timber blocking. As a full row of timber blocking was completed it was tied together by 3-in. planks reaching lengthwise of the pier. This blocking procedure was repeated until the truss shoes were within 18 in. of their final height, then the plank blocking pieces were laid lengthwise of the pier instead of across pier and four rows under each shoe and each stringer end. Next these four rows of plank blocking were removed one at a time and replaced by 18-in. I-beams. These I-beams were then connected by batten plates. The next step was to saw through the tie planks and remove the three rows of 12x12-in. blocks under each shoe. These spaces were then boarded in and concrete blocks cast in place with their tops flush with the tops of the I-beams. Then the remainder of the blocking was removed and replaced with concrete. Adjustment of the bridge ends on the new masonry completed the work.

The raising operation was conducted without getting the spans out of true except for a lateral shift of 2 in. at one abutment which was easily rectified by jacking. The work was done by company forces under the direction of Master Carpenter E. W. Holmes, to whom we are indebted for the information given in this article.

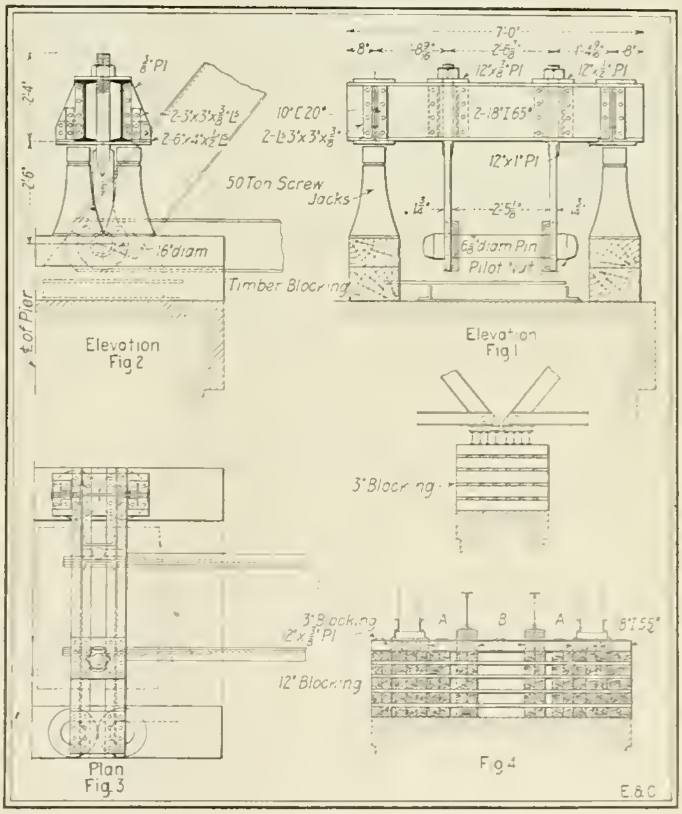

Fig. 2. Blocking and Jacks for Raising Bridge.

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The work of wrecking the buildings of the Panama Pacific Exposition at San Francisco is being done largely with dynamite.

## CONCRETING SMALL PIERS FOR BOAT HOUSE USING TREMIE.*

The project as authorized provided for the construction of 12 concrete and granite piers, ranging in over-all height from 8 to 14 ft., the granite extending from elevation —0.5 to elevation +4.92. This type of pier was proposed because of the excessive ice action at the location of the boathouse, due to the shallow water and strong currents through the boathouse channel. A typical pier is shown in Fig. 1. Several methods were considered for placing of the concrete, including (1) premolding, (2) the use of a cofferdam, and (3) tremie. The first method was rejected as impracticable, because of the uncertainty of the bottom elevation, making it impossible to determine the exact size of blocks, and because of the difficulty of placing and aligning accurately after casting; the second was given up because of the excessive cost, and the lack of such apparatus as pumps, a pile driver that would handle sheeting, etc.; while the third-pouring in place by tremie—was decided upon as being the only feasible method, considering the nature of the work, the location, the cost, and available plant.

The excavation was made with a ½-yd. bucket mounted on a small power derrick. The material excavated was soft silt and gravel. As the excavation for each pier was completed, the form, having been previously built, was placed. All forms were carefully made of 2x6-in. tongued and grooved yellow pine with 4x4-in. rough corner braces. The lower ends of the corner pieces extended about 6 in. below the form proper. After placing, dredged material was back filled around the lower part of the form to prevent the concrete from working out and to keep the form from moving laterally while pouring. Eight 90-lb. lead mine weights were hung on the outside of each form to overcome buoyancy.

The layout of the plant is indicated in Fig. 2, and consisted of a ½-yd. Austin cube concrete mixer operated by a 10-hp. gasoline motor, a 15x30-ft. steel float carrying the fixed tremie hopper and frame and a large floating pile driver on which was rigged a jury boom carrying a 9-cu. ft. concrete bucket. A 15-in. tremie pipe was used, suspended from the underside of the fixed hopper by two 3-ton differential hand-operated tackles, capable of raising the tremie easily and rapidly when full of concrete. The tremie was in two sections, one piece 15 ft. long and one piece 2 ft. 6 in., the smaller section being used with the 15-ft. piece to secure sufficient length for the deepest forms. To the upper part of the tremie pipe was attached a hopper 3 ft. high, 36 in. in diameter at the top. The upper, or fixed, hopper had a capacity in excess of the volume of the larger section of pipe. This capacity was necessary in order to insure filling the tremie above the height of the water with the first batch of concrete. A 1-2-3.5 concrete was used. The stone was crushed granite 1 in. and down; sand ¼ in. and under, clean and very well graded. The resulting mix flowed and handled well and remained plastic for a considerable length of time. The concrete was conveyed from the mixer to the bucket, on the lower platform, through a tin-lined wooden chute 12 in. wide and 10 in. deep, the flow being regulated at the mixer. To prevent loss of concrete, however, the lower end of the chute was fitted with a sliding gate and the sides increased in height to 24 in.

The concrete was carried from the loading platform to the large upper hopper by the improvised derrick boom on the pile driver. See Fig. 3. The flow from this hopper into the tremie was regulated by a flat slide valve operated from the platform at the top of the tremie frame. When the large hopper, holding about 25 cu. ft., was filled with concrete, the tremie was lowered to the bottom, then raised so as to be just clear. A sack filled with hay was then placed in the tremie, floating at the surface of the water. The valve in the upper hopper was then quickly opened wide; the flow of concrete forced the bag to the bottom of the pipe, carrying all water out with it. When the tremie was filled to a point about 2 ft. above the outside water surface, it was slacked back so as to rest on the bottom, checking further flow. As more concrete was deposited in the upper hopper and allowed to flow into the tremie pipe, the tremie was slightly raised, permitting the concrete to flow out into the form. After the form had started to fill, the bottom of the pipe was kept submerged in the concrete about 12 in. In this way one surface only was presented to the action of the water. Great care had to be exercised in regulating the height of the tremie, especially when concrete was discharged from the upper hopper, as, with the release of weight of this concrete from the smaller scow, the scow would rise quickly, carrying the tremie with it. Fortunately, only once during the entire work was the concrete in the pipe lost.

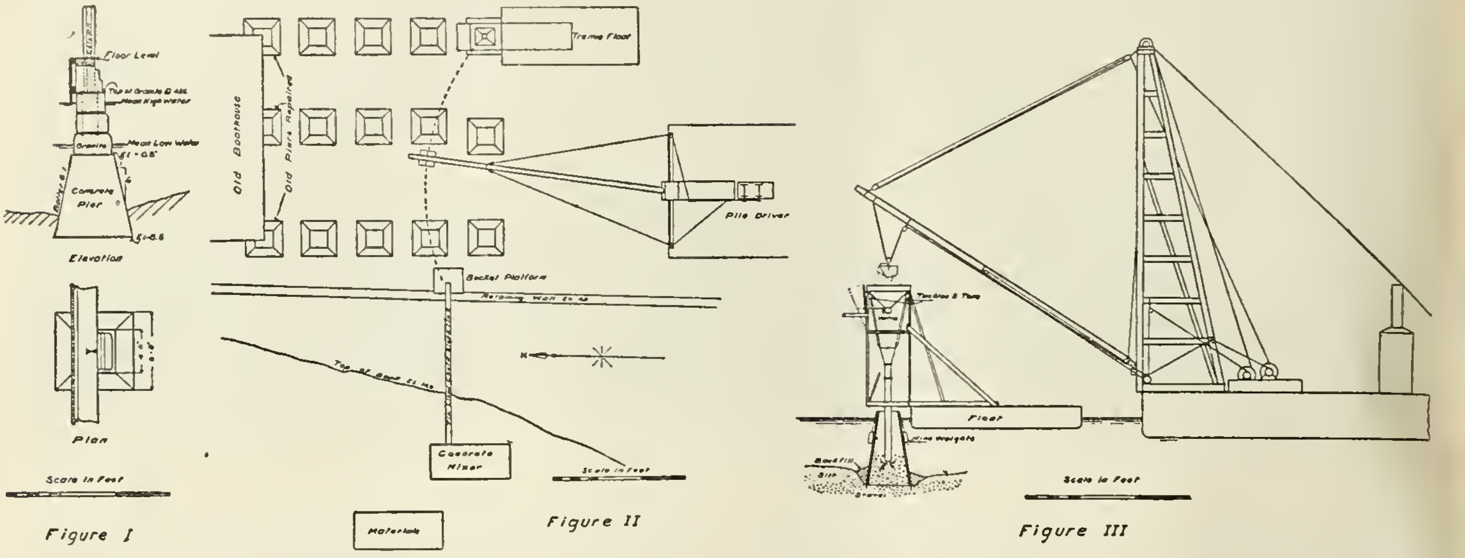

Figure I

Figure II

Figure III

Figs. 1-3. Tremie Plant for Concreting Boat House Piers.

| | Quantity. | Unit cost. | Total cost. Material. | Total cost. Labor. | Total cost. Total. |
|---|---|---|---|---|---|
| Excavation | 150 cubic yards | $1.65 per cubic yard | ....... | ....... | $ 253.52 |
| Forms | 1,440 square feet contact | $0.147 per square foot contact surface;<br>$1.93 per cubic yard concrete. | | | |
| | 3,640 feet b. m. | $0.058 per foot b. m. | $104.80 | $106.56 | 211.36 |
| Concrete | 109 cubic yards | $9.91 per cubic yard | 503.90 | 577.35 | 1,081.25 |
| Granite | 25 cubic yards | $23.86 per cubic yard | 422.10 | 174.50 | 596.68 |
| Total | | | ....... | ....... | $2,142.81 |

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*Extract from a paper by Civil Engineer Kirby Smith in Public Works of the Navy for March, 1916.

The pouring of two piers a day was considered good progress, as the work had to be conducted only at favorable stages of the tide. The form was filled to about mean low water and then later cut off to the required elevation. This insured a firm, hard base for the granite.

The granite was placed from a small wooden float on which a hand derrick was rigged. The cost of the work, including the cost of rigging the pile driver, building frame for tremie, and cost of the tremie, follows:

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## HOIST USED ON A SEVEN-STORY CONCRETE WAREHOUSE, LOS ANGELES HARBOR, CALIFORNIA.

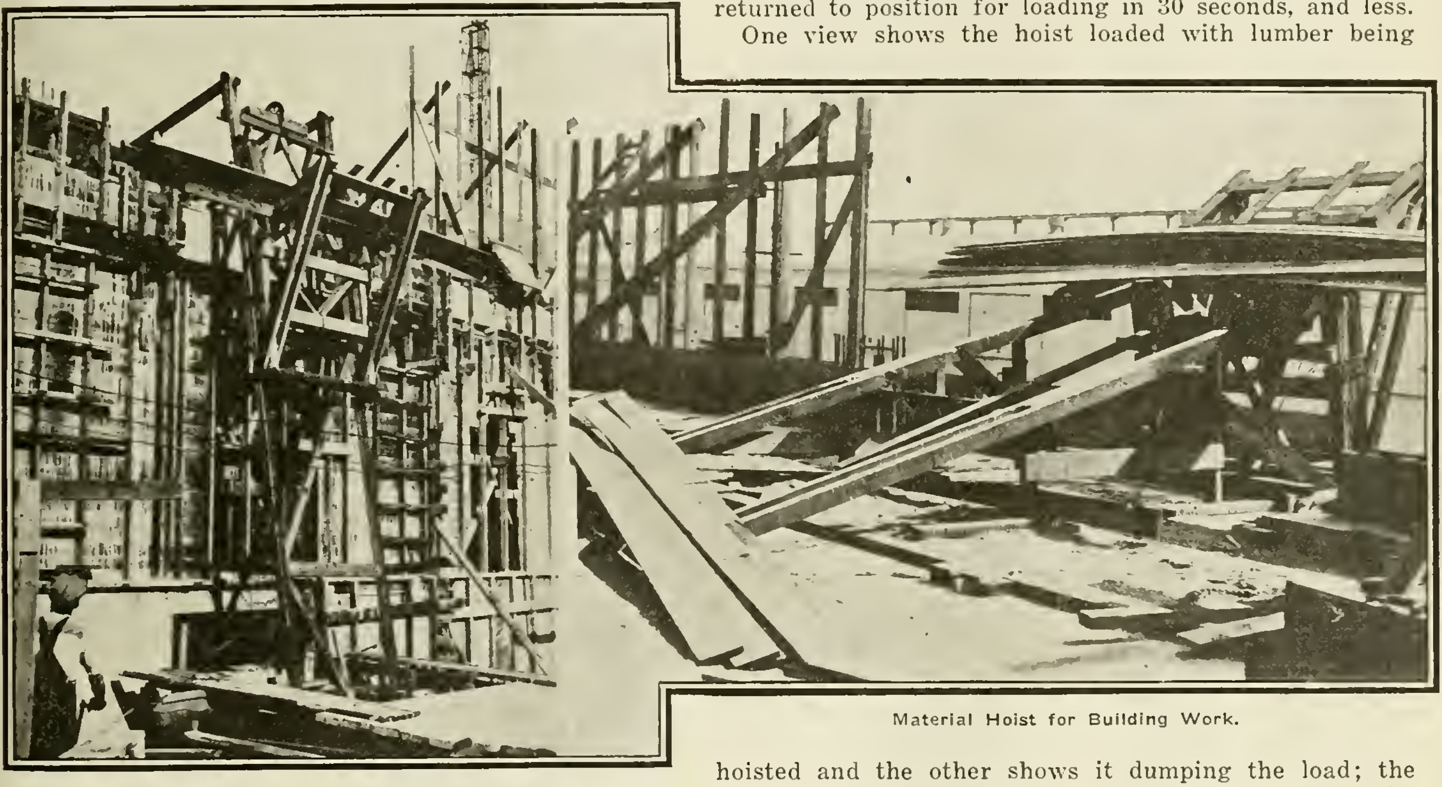
Contributed by W. D. Jones, Assistant Engineer, Harbor Department, Los Angeles, Cal.

In the construction of a seven-story concrete warehouse by the Merchants' Realty & Investment Co., of Los Angeles, for the city of Los Angeles Harbor Department, some method of hoisting materials from the street level, where they were delivered, to the upper floors of the building was desired and considerable thought was given to the design and construction of a rig that would do the work successfully. The hoist shown was constructed and proved exceptionally satisfactory in hoisting such material as spiral reinforcing, steel bars, form lumber, form panels and in fact almost anything except concrete that was desired on the upper floors. The novel feature is the dumping arrangement, which was very successful. Material was loaded into the V made by the inclined platform on the one side and by two hinged runners on the other, the platform being stationary with reference to the hoist and the runners movable, one end of the latter being hinged to the inclined platform by bolting and the other running on 4x4-in. guides. When runners passed the top of the guides the material piled against them was automatically dumped by runners laying over on the receiving timbers inclined downward.

The incline was such as to clear the hoist of material by gravity in almost all cases. The building being constructed is 480 ft. long and two of these hoists were built and located at about the center of each half of the building. One 10 H. P. General Electric motor, gear connected to a hoisting drum, operated both hoists, being moved from one to the other as progress required, the motor being set off to one side of the hoist in order not to interfere with men loading from either the front or sides. A cable was run through a pulley at ground level, then up over the 12-in. sheave at the top of the guide timbers and the end connected to the middle transverse timber in the hoist to allow the top of the hoist to pass the sheave and to dump. The guide posts were built in sections, each section being the height of a story, so that to change the level of the point of discharge the necessary sections were added or taken off as the case might be. The position of the guides in the plan is shown vertical, but it was found expedient to incline these so that they rested against the building at floor level to which material was being hoisted.

This made dumping a little more positive, as it increased the angle of platform floor with a horizontal line and consequently the angle of the receiving timbers, which skidded the material out on to the floor of the building. The elevation of the lower floor was such, with reference to the street alongside the building, that workmen could load directly into the hoist from the street level, but were this not the case, a platform and incline could be constructed to accomplish this result. After material was loaded on to the hoist the writer timed several trips and they were made 25 ft. high, material dumped and hoist returned to position for loading in 30 seconds, and less.

One view shows the hoist loaded with lumber being hoisted and the other shows it dumping the load; the hinged runners, having straightened out, are under the pile.



Material Hoist for Building Work.

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## A STUDY OF EFFECTIVE WIDTH OF REINFORCED CONCRETE SLABS.*

The theory applied to the design of narrow rectangular reinforced concrete beams involves the assumption that the stress is constant throughout the width of the beam. In a wide slab the stress distribution varies from a maximum at the point of application of the load to a minimum at the extreme edges. Obviously then, if the rectangular beam theory were applied to the design of slabs under concentrated loads, the width b used in the design formulas can not be taken as the entire width of the slab. The rectangular-beam theory, however, could be utilized in wide-slab design if it were known what width b, termed effective width, should be substituted in the design formulas. Values for effective width were obtained from the steel deformations, as well as from the concrete deformations, but it was found that the concrete deformations gave the most conservative widths, and these were therefore plotted.

In Fig. 1 the effect of variation in thickness of slab on effective width may be seen. Note that as the thickness increases, the effective width decreases, varying from 109 per cent of the span length for a 6-in. slab to 75 per cent of the span for a 10½-in. slab. The least value for effective width shown by these tests is roughly, then, about 0.7 of the span length. Judging from the curve of variation, it would seem that under extremely heavy loads, requiring very thick slabs, the effective width might be decreased as low, possibly, as 0.6 of the span length. However, 0.7 of the span will always be safe, and in general is a sufficiently conservative figure to use.

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*Extract from paper by A. T. Goldbeck and E. B. Smith in Journal of Agricultural Research, Department of Agriculture, Washington, D. C., May 8, 1916.

The usual rectangular-beam design formulas may be applied to the design of slabs by merely substituting for b its value as determined by these investigation, $b = 0.7L$. The corresponding formulas then become:

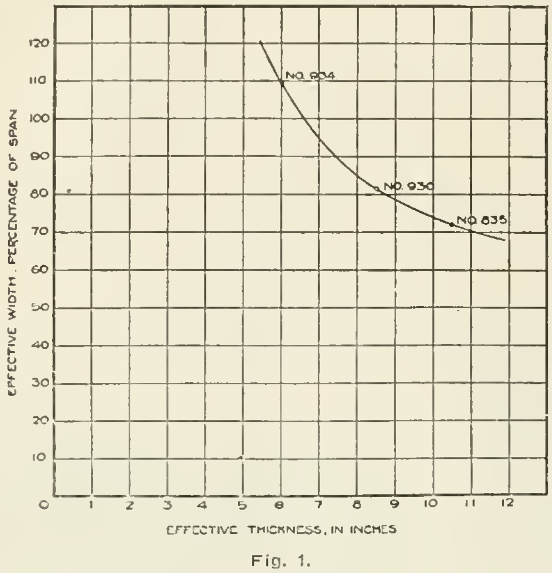

Fig. 1.

| | For Rectangular Beams. | For Slabs Under Central Concentrated Loads. |
|---|---|---|
| (1) | $M_c = \frac{1}{2} f_c kjbd^2$ | $M_c = \frac{1}{2} f_c kj \frac{7}{10} Ld^2$ |
| (2) | $M_s = pf_s jbd^2$ | $M_s = pf_s j \frac{7}{10} Ld^2$ |
| (3) | $p = \frac{a_s}{bd}$ | $p = \frac{10a_s}{7Ld}$ |
| (4) | $p = \dfrac{\frac{1}{2}}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)}$ | $p = \dfrac{\frac{1}{2}}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)}$ |
| (5) | $k = \sqrt{2pn + (pn)^2} - pn$ | $k = \sqrt{2pn + (pn)^2} - pn$ |

It is interesting to note that in substituting for $M_c$ and $M_s$ in formulas 1 and 2 their value $\frac{PL}{4}$, the L's cancel, showing that the safe load-carrying capacity of the slab is independent of the span; thus—

$$1 \text{ becomes } \frac{PL}{4} = \tfrac{1}{2} f_c kj \frac{7}{10} Ld^2 \quad \text{or} \quad P = \frac{7}{5} f_c kjd^2$$

$$2 \text{ becomes } \frac{PL}{4} = pf_s j \frac{7}{10} Ld^2 \quad \text{or} \quad P = p \frac{14}{5} f_s jd^2$$

The above investigations were made on slabs the width of which was twice the span length, so that the stress at the extreme edges was very small. The conclusions must therefore be applied to such cases only. When the ratio of width of slab to span length is less than 2, these conclusions may or may not apply, and additional investigations are now being made to determine the proper value of effective width to use under such condition.

## THE THICKNESS OF FLAT SLAB FLOORS.

Contributed by Henry T. Eddy, Professor and Dean Emeritus, University of Minnesota.

The correct thickness of a reinforced flat slab depends not only upon the distance between centers of supports and upon the design load, but upon the diameter of the column cap and upon the steel ratio in such a complicated manner that it is impossible for it to be determined directly from geometrical and mechanical considerations, especially in view of the fact that the resisting moment of the steel is the product of the unit stress times the cross section of the reinforcing steel multiplied by its arm, and either of these last two factors may consequently be varied at the expense of the other without varying their resisting moment.

It is highly desirable therefore to employ some empirical formula for the thickness of the slab from which a value may be obtained that is based on such a wide range of successful construction as to give confidence in its reliability. and that at the same time is as simple as possible.

In the foregoing statement it is implied that it is quite possible to design slabs of different thicknesses for the same span and design load and yet so proportion them that they will all have the same strength. Their stiffness will, however, be different, and some of these designs will be more economical than others. Balanced reinforcement will not necessarily nor probably furnish the most economical design, nor one that is the stiffest, nor one that is the most advantageous from every point of view.

As a general principle it is advisable to have the slab so designed that the concrete in the compression zone is stronger than the steel in the tensile zone, because the steel has more definite and better known properties than the concrete, and in case the steel is the weaker element, since the strength of any structure depends upon its weakest element, the strength of the slab may then be known with certainty, because it will depend upon the properties of such a dependable element as the steel and not upon an unreliable and fragile material like concrete. This will require that the slab be under-reinforced and not over-reinforced.

Perhaps the most dangerous fallacy common respecting flat slabs is in making the assumption that it is advantageous to so greatly increase the percentage of steel as to cause over-reinforcement, a thing that is easy to do since slabs require only about half the percentage of belt reinforcement needed by beams.

This principle of under-reinforcement fixes an upper limit to the permissible or available steel ratio in slabs, which in turn fixes their minimum thickness in a manner similar to the minimum thickness of beams as has been determined in our treatise on Concrete-Steel Construction, page 86.*

It has been found that a formula for the effective thickness d and the total actual thickness h of a flat slab which will express the values of these quantities in inches with great accuracy is of the following forms, viz.:

$$d = h - a = L'(w_0 + b)/c$$

In this $L'$ = the span from center to center of supports in feet; $w_0$ = the total design working load in pounds per square foot; a = the mean vertical distance at mid span in inches from the center of action of the steel to the bottom of the slab, assumed as ⅞ in. = 0.875 for reinforcement consisting of ⅜ in. round rods, and as 1 in. for ½ in. rounds while b and c are constants determined so as to adjust the formula to safe practice. It will be observed that $w_0$ in the formula is the working live load per square foot at any span whatever and b and c are so determined that $L'$, $w_0$ and h or d in the formula may be regarded for graphical purposes as co-ordinates of a ruled surface in which, if $L'$ and $w_0$ be used as rectangular co-ordinates in a horizontal plane, h or d is the vertical distance or ordinate of the surface above that plane, but the plane from which d is measured is ⅞ in. above that of h. This surface is an elementary doubly ruled surface known as a hyperbolic paraboloid in which at any given or assumed

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*Eddy and Turner, Minneapolis, 1914.

TABLE I. -TOTAL THICKNESS h OF ROUGH SLAB WITH ⅜-IN. ROUND RODS.

$h = 0.87 + (4 W_o + 2800) L'/10^4 = 0.87 + d$ inches.
$L'$ = span in feet. $W_o$ = live load in lb. per sq. ft.

| L′ = ft.. | Wo = 80. | 100 | 125 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14x14 | 5.24 | 5.35 | 5.49 | 5.63 | 5.91 | 6.19 | 6.47 | 6.75 | 7.03 | 7.31 | 7.59 | 7.87 | 8.15 |
| 15x15 | 5.55 | 5.67 | 5.82 | 5.97 | 6.27 | 6.57 | 6.87 | 7.17 | 7.47 | 7.77 | 8.07 | 8.37 | 8.67 |
| 16x16 | 5.87 | 5.99 | 6.15 | 6.31 | 6.63 | 6.95 | 7.27 | 7.59 | 7.91 | 8.23 | 8.55 | 8.87 | 9.19 |
| 17x17 | 6.18 | 6.31 | 6.48 | 6.65 | 6.99 | 7.33 | 7.67 | 8.01 | 8.35 | 8.69 | 9.03 | 9.37 | 9.71 |
| 18x18 | 6.47 | 6.63 | 6.81 | 6.99 | 7.35 | 7.71 | 8.07 | 8.43 | 8.79 | 9.15 | 9.51 | 9.87 | 10.23 |
| 19x19 | 6.80 | 6.95 | 7.14 | 7.33 | 7.71 | 8.09 | 8.47 | 8.85 | 9.23 | 9.61 | 9.99 | 10.37 | 10.75 |
| 20x20 | 7.11 | 7.27 | 7.47 | 7.67 | 8.07 | 8.47 | 8.87 | 9.27 | 9.69 | 10.07 | 10.47 | 10.87 | 11.27 |
| 21x21 | 7.43 | 7.59 | 7.80 | 8.01 | 8.43 | 8.85 | 9.27 | 9.69 | 10.11 | 10.53 | 10.95 | 11.37 | 11.79 |
| 22x22 | 7.74 | 7.91 | 8.13 | 8.35 | 8.79 | 9.23 | 9.67 | 10.11 | 10.55 | 10.99 | 11.43 | 11.87 | 12.31 |
| 23x23 | 8.05 | 8.23 | 8.46 | 8.69 | 9.15 | 9.61 | 10.07 | 10.53 | 10.99 | 11.45 | 11.91 | 12.37 | 12.83 |
| 24x24 | 8.36 | 8.55 | 8.79 | 9.03 | 9.51 | 9.99 | 10.47 | 10.95 | 11.53 | 11.91 | 12.39 | 12.87 | 13.35 |
| 25x25 | 8.67 | 8.87 | 9.12 | 9.37 | 9.87 | 10.37 | 10.87 | 11.37 | 11.87 | 12.37 | 12.87 | 13.37 | 13.87 |
| 26x26 | 8.99 | 9.19 | 9.45 | 9.71 | 10.23 | 10.75 | 11.27 | 11.79 | 12.31 | 12.83 | 13.35 | 13.87 | 14.39 |
| 27x27 | 9.30 | 9.51 | 9.78 | 10.05 | 10.59 | 11.13 | 11.67 | 12.21 | 12.75 | 13.29 | 13.83 | 14.37 | 14.91 |
| 28x28 | 9.61 | 9.83 | 10.11 | 10.39 | 10.95 | 11.51 | 12.07 | 12.63 | 13.19 | 13.75 | 14.31 | 14.87 | 15.43 |
| 29x29 | 9.92 | 10.15 | 10.44 | 10.73 | 11.31 | 11.89 | 12.47 | 13.05 | 13.63 | 14.21 | 14.79 | 15.37 | 15.95 |
| 30x30 | 10.23 | 10.47 | 10.77 | 11.07 | 11.67 | 12.27 | 12.87 | 13.47 | 14.07 | 14.67 | 15.27 | 15.87 | 16.47 |
| 31x31 | 10.55 | 10.79 | 11.10 | 11.41 | 12.03 | 12.65 | 13.27 | 13.89 | 14.51 | 15.13 | 15.75 | 16.37 | 16.99 |
| 32x32 | 10.86 | 11.11 | 11.43 | 11.75 | 12.39 | 13.03 | 13.67 | 14.31 | 14.95 | 15.59 | 16.23 | 16.87 | 17.51 |

value of L′ the thickness h increases uniformly with $w_0$, and at any given value of $w_0$ the thickness increases uniformly with L′. Using convenient approximate values of a, b and c for ⅜-in. round reinforcing rods the formula may be written in the following form:

$$h = 0.87 + L' (w_0 + 700)\ 2500 \ldots\ldots\ldots\ldots (1)$$

in which h = the total thickness of the slab in inches, and L′ = the distance in feet from center to center of supports of a square panel, while $w_0$ = the working live load per square foot of panel in pounds.

The manner in which the numerical values of b and c given in (1) were obtained by calculation from any two known thicknesses when once the general form first given had been assumed is as follows:

It is known from experience that for a 17-ft. panel and a design live load of 200 lb. per square foot h = 7 in. nearly, and for a 23-ft. panel and a design live load of 400 lb. per square foot h = 11 in. nearly. Hence the general formula for these two loads and these spans reduces to

$$7 = 0.87 + 17(200 + b)\ c$$
$$11 = 0.87 + 23(400 + b)\ c$$

Hence, b = 700 and c = 2,500 nearly. Formula (1) may also be written in a form convenient for calculation as follows:

$$h = 0.87 + 0.0001\ L' (4w_0 + 2{,}800) \ldots\ldots\ldots\ldots (1)_1$$

In Table I are given the numerical values of the thickness h for various spans L′ from 14 to 32 ft. and various live loads $w_0$ from 80 to 600 lb. per square foot calculated in accordance with formula $(1)_1$. The work of calculating this table is greatly facilitated by noting that for any given value of L′, h varies as $w_0$, and for any given value of $w_0$, h varies as L′; that is, there is a constant difference in the values of h per hundred pounds along any given horizontal line and a constant difference per foot of span down any given column of the table.

The values of h given in Table I agree closely with the values of the design thickness given in the standard tables employed for Mushroom slabs from which the floors of more than 2,000 buildings have been successfully constructed, but the values in Table 1 are very slightly in excess of those found in these standard tables for large spans and heavy live loads.

It seems desirable to prescribe a minimum thickness of h = 6 in. which should be adopted in practice in place of the few slightly smaller values computed in Table I.

In case of rectangular panels the span of the longer side of the panel is that designated by L′, for, the thickness of a floor consisting of rectangular panels not square should be the same as that of a floor of square panels having the same total load and the same span as the longer side of the rectangular panels, because for the same load the bending moments across the belt on the longer side will be the same in both cases and further the thickness should be governed by the moments at midspan across this side rather than by those across the shorter side, since they are the larger.

In order to compute the dead load of the slab per square foot assume that reinforced concrete weighs on the average 150 lb. per cubic foot or 150/12 = 12.5 lb. per inch of thickness per square foot of slab. The dead load $w_1$ per square foot consequently may be calculated from h the thickness in inches as follows:

$$w_1 = 12.5\ h = 100h/8 \ldots\ldots\ldots\ldots (2)$$

The value of $w_1$ for the several thicknesses already computed is readily calculated by (2) and tabulated. The value of the total load is therefore—

$$w = w_0 + w_1 \ldots\ldots\ldots\ldots (3)$$

which is the sum of the live and dead loads per square foot of slab. This may also be readily tabulated for the same live loads and spans as in Table I. Tabular increments for (2) or (3) are constant for equal increments of L′ or $w_0$.

A formula for the minimum thickness of flat slabs different from (1) has recently been proposed in the new ruling on the design of reinforced concrete flat slab floors in the city of Chicago,* as follows:

$$h = .032L'\sqrt{w} \ldots\ldots\ldots\ldots (1)_2$$

in which L′, w and h have the meanings already defined in equations (1) and (3), except that L′ is "defined as the average distance center to center of columns of the long and short sides of a rectangular panel."

It is somewhat tedious to compute values of h by this formula $(1)_2$ because the dead load depends upon the thickness which is to be computed, a fact which necessitates repeated trials to find h, a difficulty avoided in equations (1) and $(1)_1$. If, however, a table of values of h be computed from $(1)_2$, like Table I, it will be found that the values of h so computed which lie on a diagonal line across the table from the lower left-hand corner where L′ = 32 and $w_0$ = 80 to a point on the upper line where L′ = 14 and $w_0$ = 400 are nearly identical with those in Table I, but that $(1)_2$ gives values of h that are increasingly larger than those in Table I the nearer they lie to the lower right-hand corner of the table. At L = 32, $w_0$ = 600, the value of h so computed would be nearly 22 in. instead of 17.5 in. as given in Table I, and at L′ = 32 and $w_0$ = 400 the value of h would exceed that in Table I by more than 3½ in.

Again $(1)_2$ gives increasingly smaller values of h than those in Table I for all points which lie nearer the upper left-hand corner at L′ = 14 and $w_0$ = 80, at which point the difference amounts to more than 1 1/3 in.

But these last excessively small and inadmissible values of the thickness are taken care of in the Chicago ruling by a special blanket clause providing that "in no case shall the slab thickness be less than one thirty-second (1/32) of the panel length for floors, one fortieth (1/40) for roofs, and also not less than 6 in." This last clause would need to be applied to all points of a table of values for h computed by equation $(1)_2$ between the upper left-hand corner and a diagonal line drawn from L′ = 22′, and $w_1$ = 80 lb., to L′ = 14′ and $w_0$ = 300, while the clause requiring h > L/32 would apply to all points in the table where $w_0$ < 200 lb. approximately. Any ruling in which the exceptions cover so large a part of the usual run of buildings evidently cannot be regarded as having any scientific or theoretically correct basis.

It is stated, however, in the paper previously referred to that $(1)_2$ is based on an accumulation of test results in the office of the Chicago Building Department from which the data respecting 10 selected buildings are tabulated.* It seems desirable to compare the actual thicknesses h of these 10 selected slabs with the thickness $h_1$ calculated according to $(1)_1$ and the thickness $h_2$ according to $(1)_2$, as shown in the accompanying table. The values of $h_2$ as given are only approximate and are based on a dead load due to a thickness h. They are consequently all except No. 9 somewhat larger than would be obtained by a more exact calculation. It is evident that so far as these thicknesses are concerned which were specially selected to support $(1)_2$ they are more nearly in accordance with $(1)_1$ than with $(1)_2$.

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*See Engineering News, Sept. 24, 1914, page 632.

| | Building. | h. | $h_1$. | $h_2$. |
|---|---|---|---|---|
| 1. | Lyon & Healy | 7.5 | 8 | 7.1 |
| 2. | Ill. Wall Paper | 8.5 | 8.4 | 7.5 |
| 3. | Ed. Katzinger | 8 | 7.4 | 7.4 |
| 4. | Sears-Roebuck | 8 | 7.4 | 7.2 |
| 5. | Adam Schaaf | 8 | 7.4 | 7.2 |
| 6. | H. Exp. & Van | 6.5 | 6 | 4.8 |
| 7. | Am. Book Co. | 10 | 8.6 | 9.2 |
| 8. | Int. Register | 7.5 | 6.2 | 6.5 |
| 9. | Donnelly | 11 | 10.8 | 11.8 |
| 10. | Ford Motor | 11 | 10.4 | 10.3 |

The same is true of the data contained in a table of buildings built on the Acme System given by Mr. Condron of Chicago, the designer of two-way flat slabs, tabulated in a paper by him on page 8 of the Western Contractor, Kansas City, March 12, 1913, in which the deviations of the actual thicknesses from the values calculated by $(1)_2$ are very striking, while the values calculated by $(1)_1$ are mostly in good agreement with the thicknesses of the slabs as actually built. So far as can be seen from these comparisons $(1)_1$ accords much more closely with accepted practice than does $(1)_2$. For large spans and heavy loads the divergence of $(1)_2$ and $(1)_1$ is relatively so large as apparently to make thicknesses computed according to $(1)_2$ prohibitive by reason of the large useless additional dead load called for.

There are three criteria according to which judgment may be passed upon the correctness of the thicknesses as above computed.

One of these has already been mentioned, namely, good agreement with a wide range of common practice, which would usually be regarded as an ample and sufficient basis for an empirical formula, and in fact is the only basis adduced in favor of the Chicago Ruling, but as has been shown the agreement in that case is not so good as is desirable.

The second criterion is that the thickness shall not be so small as to produce undue compressive stresses in the slab nor require an unduly high percentage of steel. The fulfillment of this second criterion depends upon the existence and validity of a complete analytical theory of the stresses in flat slabs such as the present writer has developed elsewhere, by which thickness as above computed has been found sufficiently large to fulfill all requirements of this nature.

The third criterion requires that the thickness shall not be so small as to allow deflections that are prohibitive from a structural or practical standpoint. It has been found that all requirements of this kind are also fully met by the thickness as above computed.

## LARGE BRIDGE PIER CONSTRUCTION USING STEEL FORMS.

(Contributed.)

The views accompanying illustrate a construction detail of the new railway bridge being built across the Ohio River at Metropolis, Ill. The eight main span piers and the approach viaduct pedestals of this bridge are concrete and are being molded in all details by steel forms. We believe that this is the most notable recorded use of steel forms in bridge pier construction. This bridge is notable in several particulars. It connects the Atlantic Coast Line and the Louisville & Nashville railways with the Chicago, Burlington & Quincy and Great Northern railways, thus linking up a great transcontinental system. It contains the longest simple span ever constructed. It uses silicon steel and nickel steel for all main truss members.

The present season will probably see the completion of all the masonry for the bridge, the erection of approaches on both the Illinois and Kentucky shores, and the completion of three of the seven river piers. Material progress has been made on the work, and with a favorable river stage, it is predicted that the bridge will be finished ahead of the time originally estimated, as at present the forces engaged in the construction are in advance of the schedule.

The bridge is of more than ordinary interest from an engineering standpoint. It will have one of the longest simple truss spans of any bridge in the world, the main channel span being 720 ft. which, according to an official statement, "exceeds by 45 ft. any similar span already erected." The river piers are founded on a thick stratum of white quartz sand 75 ft. below water level. As rock is 230 ft. below the low-water elevation, rock foundations are out of the question, and the footings for the piers are of the spread type, with pronounced offsets at their connections with the shafts of the piers.

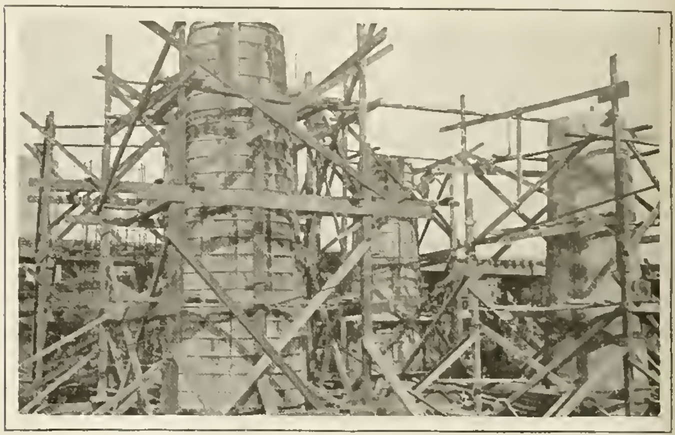
Fig. 1—Conical Pedestals for Approach Viaducts, Metropolis Bridge.

The main channel span, which is near the Kentucky shore, will be separated from the south approach viaduct by a span of 249 ft. 11 in. North of the long span there will be four spans of 557 ft. 4 in. and one span 304 ft. 3 in., all through truss type. The north approach, on the Illinois side, consists of 1,590 ft. of steel viaduct, and the south approach, on the Kentucky side, of 600 ft. of viaduct.

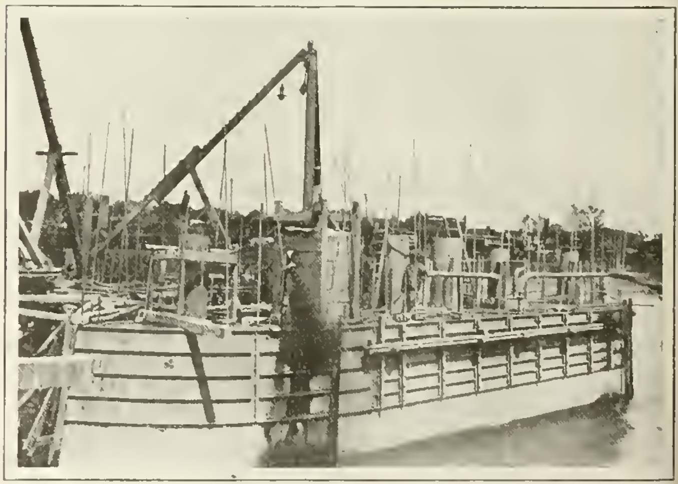
Fig. 2—Forms for Cutwater Portion of Main Pier.

Within the past year the north approach has been completed and the substructure for the south approach finished. At present work is progressing satisfactorily on the superstructure of the south approach. The work on the piers for the main span, using the pneumatic process and Blaw steel forms, has been under way for about a year.

The track on the channel span will be on a level grade 113 ft. above low water with .3 per cent grades descending on either side. The difference between high and low water stages is 52.7 ft., providing a clear headroom under the bridge at high water of 53 ft. The bridge will be 5,700 ft. from end to end and 3,245 ft. long, exclusive of the approaches.

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*See Engineering News, Sept. 24, 1914, page 635.

Blaw Steel Forms are being used in the building of the piers and the pedestals for the steel work of the approaches. Over 90,000 cu. yd. of concrete and 120,000 bbl. of cement will be used. There will be 19,000 tons of steel in the bridge. The main channel pier, known as Number 6, will be 105x65 ft. at the base and will be 195 ft. high, requiring 15,000 cu. yd. of concrete. The distance from the base of this pier to the top of the main channel bridge span will be 317 ft.—higher than many so-called skyscrapers.

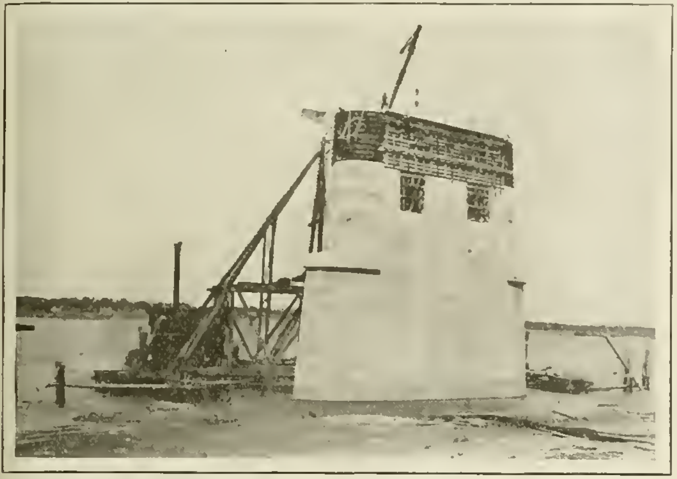


Fig. 3—Completed Pier, Showing Conical Nose Forms.

The plans of the Burlington Railroad and the Nashville, Chattanooga & St. Louis Railroad in the prosecution of this work, also contemplate the building of extensive yards on the Kentucky side of the river, and all told, within the next two years there will have been expended in this undertaking approximately $6,000,000, which includes the bridge and the construction of a 12-mile line of double-track railroad from a point near Paducah to the bridge, and which line will form the connection with the Nashville, Chattanooga & St. Louis Railway at Paducah, the connection with the Burlington being at Metropolis.

## BENSALEM AVENUE CONCRETE ARCH BRIDGE, PHILADELPHIA, PA.

Contributed by Jonathan Jones, Assistant Engineer of Bridges, Department of Public Works, Philadelphia, Pa.

The city of Philadelphia has just awarded the contract for what promises to be its most important concrete bridge, excepting only the Walnut Lane arch, which when constructed in 1908 was a pioneer in ribbed arch construction in concrete. The bridge just placed under contract is to carry Bensalem Ave. over Pennypack Creek and the Pennypack Park drives.

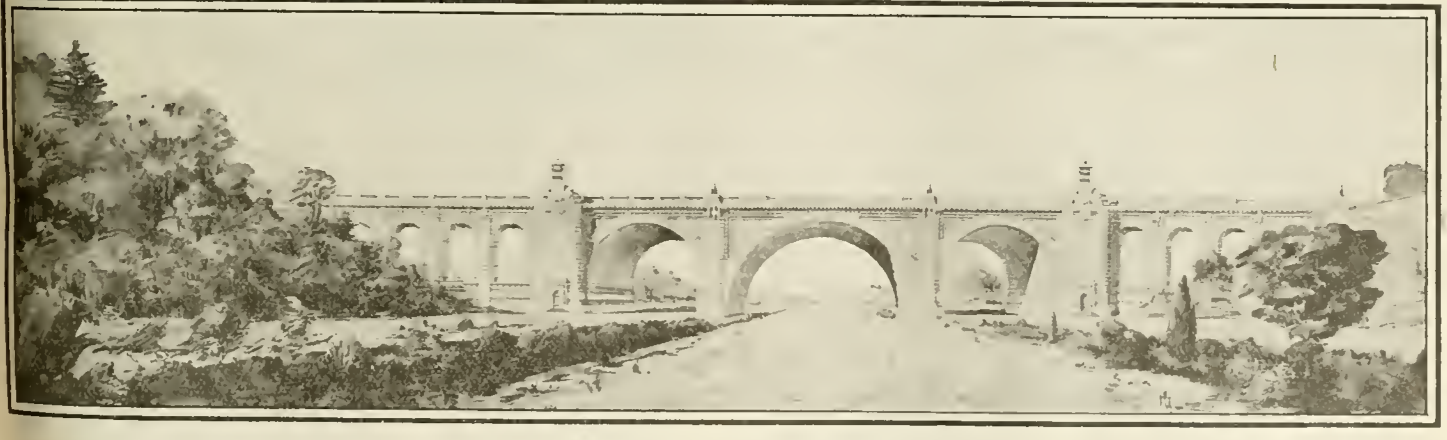


Fig. 1—Bensalem Ave. Concrete Bridge.

The city has recently completed its Northeast Boulevard, extending from a point on North Broad St. a distance of some seven miles in a general northeasterly direction and of 300-ft. width, then branching from a circular plaza into three lesser avenues of 150-ft. width each, in the direction of three important suburbs. Bensalem Ave. is the most northerly of these three branches of the boulevard, and when completed will become a part of the transcontinental or "Lincoln" Highway, and will connect Philadelphia and New York, and carry a great volume of motor traffic. It traverses rolling country, and the bridge floor is approximately 60 ft. above the stream bed. On both banks of the stream, for several miles in each direction, the city has acquired the land for the development of what is destined to be one of the most important of its parks, and the architecture of the bridge has accordingly been designed in a manner befitting the importance of the thoroughfare, and also presenting an attractive appearance as viewed from the park below.

The width of the bridge, center to center of railings, is 78 ft., which accommodates all the trafficway of the 150-ft. wide street, eliminating only the major portion of the sodding and planting spaces of the wider portion. It carries a 54-ft. cartway, which allows six lines of traffic of 9 ft. each, hence can in the future accommodate a double-track electric railway, with one fast-moving and one slow-moving line of vehicular travel in each direction outside of the tracks. By gradual curves in the curbing the two separate cartways of the 150-ft. street are gradually merged into the single driveway over the bridge.

South of the creek, the park is fairly level with the creek bank for about 80 ft., then rises sharply with a heavily wooded slope. On the northerly bank the rise is more gradual and not wooded to any extent. The approach retaining walls extend practically across the valley, it being deemed inadvisable from the park standpoint to shorten the walls for economy and to intrude 1½ to 1 or similar slopes into the natural contours of the park and to sacrifice the old timber on the south approach.

The general proportions of the structure were carefully studied in elevation and perspective, from viewpoints in the valley and viewpoints on the roadway, and tested for reasonable economy before being finally determined upon. The resulting elevation presents three elements:

(1) The principal or bridge structure of three semicircular spans, a central span of 100 ft. clear width crossing the stream, and two side spans of 60 ft. clear width, allowing for any desired development of park drives, footpaths, etc.

(2) The approach retaining walls.

(3) Massive pylons separating the bridge structure from the retaining wall approach.

The arch spans are not structurally novel. Solid spandrels were from the outset considered desirable to give a massive effect, and these were designed as gravity sections of solid concrete, with a base width of .45 the height, according to Philadelphia practice. Several alternative designs were worked up for comparative estimates, including designs which dispensed with the earth filling, thinned the spandrels to bearing walls and by interior piers or columns supported a roadway slab, and including designs which employed the earth filling, but balanced the earth thrusts by means of transverse ties from one spandrel to the other. None of these alternate schemes, however, showed any certain economy that would compensate for its complexity or for sacrificing the unlimited pipe and duct space afforded by the unobstructed earth fill. If the bridge were less wide, this result would not obtain; it is because the cost of the spandrel walls is spread over about 80 ft. of bridge width, that they do not show up badly in cost per square foot.

The 60-ft. arches are of the solid-barrel type, but with a saving of material in the piers and abutments, by the use of buttresses in the latter and cross-walls in the former. For the 100-ft. arch a small and problematical saving, certainly not $1,000, was estimated for the construction of six ribs with reinforced slabs spanning the spaces between them, the ribs being thickened at the slab supports for the additional load. At even an equal cost, however, this construction was preferred as to appearance, for it conveys the sense of direction of the principal span, while the smooth soffits of the side arches emphasize the transverse direction, which is the direction of park travel through them. A separate price was taken for the waterproofing of the extrados of all arches with asphalt mastic, and as a favorable price was received, this will be ordered.

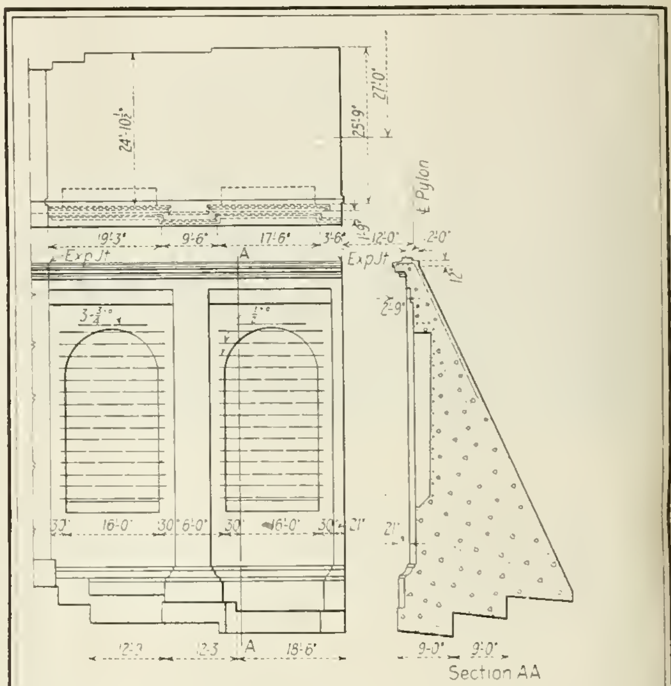
The pylons flanking the arch structure have strong projections from the general surface of the bridge and are naturally built hollow with a vertical slab in the rear transmitting the earth pressure with the aid of horizontal reinforcement, to the side of buttress walls. Since the pylons are hollow, they lend themselves to a number of possible future uses, for storage rooms, comfort stations and other park purposes, perhaps a stairway from the upper to the lower level; doorways and windows are therefore incorporated in the architectural treatment.

The high retaining walls possess possibly the greatest interest, as regards both design and the conditions of the contract letting. Walls as high as 60 ft. at the highest point naturally promised considerable economy through the use of reinforced concrete rather than the gravity type, especially since access to the bridge site is not easy and the cost of hauling is adverse to the type of design that uses the greater quantity of material.

The question of design is, however, inseparable from the question of architecture and of surface finish, for these two elements must be given weight, as well as economy, in planning so important a structure. Concrete is regarded as an acceptable substitute for stone in the construction of bridges in Philadelphia only in so far as it can be given an acceptable texture and color, either by the scrubbed or Quimby finish, or by bush-hammering and chiseling. In either case, a desirable surface requires a facing mixture different from the body concrete, using a small aggregate of ¼ to ⅜ in., either of stone chips or pebbles. For the Bensalem Ave. bridge it was felt desirable to set against the green trees and meadows of the surrounding landscape, a warm buff color which has several times been obtained by the scrubbing method, with brown and yellow pebbles (locally obtainable) for the aggregate of the facing mixture. Previous experience with facing mixtures in high, thin walls, has shown that from 3 ft. to 3½ ft. of thickness is absolutely necessary if the workman is to obtain a uniform and acceptable surface and prevent the backing mixture from working to the face in unsightly patches. This is particularly true when the reinforcement is at all heavy and near the face.

For the design, which was studied in reinforced concrete of the usual slab, platform and counterfort type, it was therefore required that the slab should have a least thickness of 3 ft. 3 in., to allow for proper manipulation of the facing. Under this restriction as to amount of material, and using reasonably higher unit prices to allow for the slower and more difficult placing and the probable working of the mixer at less than its capacity, the difference in cost of the reinforced wall was only slightly in its favor.

Further consideration led to a design, Fig. 2, in which the facing mixture was in general the only mixture on the face walls, so that this wall could be poured from above with no necessity for keeping it separated from any backing mixture. A thickness of 9 in. was determined on for this face wall, and it was of course excluded from any other duty than that of rendering the desired appearance. The earth pressure was to be resisted by a reinforced, inclined slab, back of and independent of the face wall, and carrying its strains by horizontal reinforcement, to counterforts. The front faces of these counterforts would require facing, and were designed of ample dimensions to permit of that being done. Such a design gives high toe-pressures, as the width of base is the width only of the counterforts, the face wall being arched up so as to take no foundation pressure and hence develop no cracks. In the present instance, the presence of hard rock near the surface makes these toe-pressures entirely acceptable. The apparent advantage of such a wall is that the slab which actually resists the earth thrust can be built speedily, in large sections, and with rough forms.



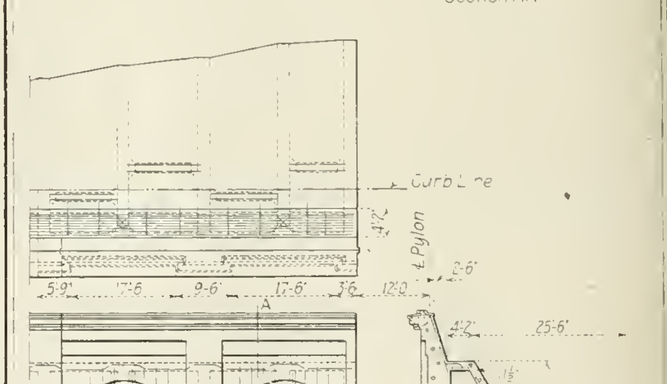


Fig. 2—Gravity Section Retaining Wall
Fig. 3—Hollow Retaining Wall.

If eventually leaks should develop at construction joints, they would be in joints parallel to the main reinforcement and would rust out only a rod or two adjacent to the joint, doing no great damage. Seepage through such joints would not reach the showing face because of the gap between.

Cost estimates indicated that such a wall would be considerably cheaper than the slab-platform-counterfort type, allowing for the additional forms and deducting for the reduction in earth fill. It promised to be several thousand dollars cheaper than a gravity wall of .45 base width, which was of course the criterion for stability used in reinforced designs. It was felt, however, that such comparative estimates should on so large a structure be checked by the taking of actual bids, and therefore the gravity design, Fig. 3, was advertised in competition with the hollow design. Five bidders submitted proposals, and of these two favored the reinforced design, while the other three bid lower on the gravity type, one by as much as $21,000.

Bids received at this particular time hardly establish any generalities, however, as the diversity of opinion among bidders is shown by the discrepancy of nearly 100 per cent between the high and low bids received. There was a difference of about 20 per cent between the lowest and second bid.

The contract was awarded to Day & Zimmerman, of Philadelphia, at an aggregate price of about $200,000. The contract includes such a diversity of items that it is impossible to compare this directly with other bridge prices. It represents about $4.15 per square foot, including the fill in place without paving.

This contract is under the direction of Mr. George E. Datesman, Director, Department of Public Works; Mr. Chester E. Albright, Chief Engineer, Bureau of Surveys. Mr. Jonathan Jones, Assistant Engineer, is in charge of the Bridge Division and directly responsible for design and construction.

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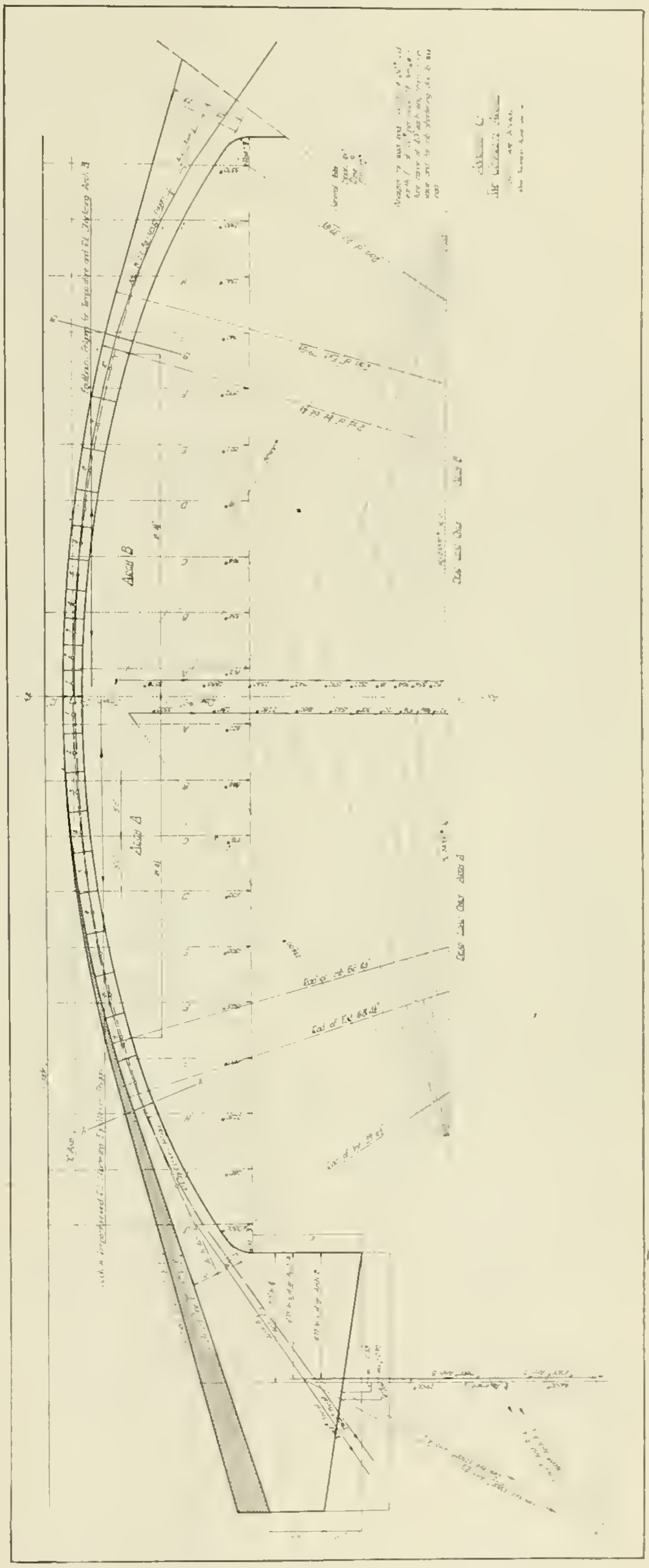
## THE ECONOMICAL SECTION FOR SHORT SPAN, REINFORCED ARCHES CARRYING LIGHT HIGHWAY LOADINGS.

Contributed by C. B. McCullough, Assistant Highway Engineer, Iowa Highway Commission.

Until quite recent years, when the development of highway engineering has directed the attention of engineers and designers to the possibility of concrete and reinforced concrete for short span highway bridge construction, careful analytical designing, particularly of arch structures, has been largely limited to those wherein the live loadings were relatively heavy and thus a governing factor in the design. We find a great deal of literature available concerning the "linear arch" for different assumptions of loading (notably the Parabola, the Transformed Catenary and the "Geostatic" curve of Rankine), or concerning the enveloping curves of an assumed middle third area of which the method of Alexander and Thompson is typical. The apparent purpose of all investigations of this type has been to reduce dead and to some extent live load stresses by a proper selection of the axial curve of the arch. For ordinary loadings such information is of great value to the designer. In the design of the short span, spandrel filled arch, for the lighter highway loadings, however, other factors entering into the design (particularly in localities having climatic conditions such as obtain in the northern middle west) render the selection of the depth of ring section and its method of varying from crown to spring line of equal if not greater importance than that of the axial curve.

It is a fact well known to all designers that the moments induced in a fixed arch by internal temperature changes will vary as the moment of inertia of the section and thus very nearly as the cube of the depth of section. (This relationship is absolutely true for plain sections and very approximately so for reinforced sections.) The moment of resistance of these same sections varies as the second power of the depth of section (strictly true for plain and approximately so for reinforced sections). Obviously then the fibre stress induced by the above forces will vary almost directly as the depth of section. (This relationship is somewhat modified by the direct stress, the effect of which is to increase the fibre compression and decrease the fibre tension for a rise in temperature and to modify in a reverse order for a temperature drop, but the effect of such direct stress is not large.)



Concrete Arch Stress Analysis.

While the above relationships hold equally well for structures designed for heavy live loading it is usually the case that the decrease in dead and live load fibre stress always incident to an increase in section will be

TABLE 1.—COMPARATIVE STRESS VALUES IN ARCH RINGS A AND B.

| Section. | Loading. | Moment | | Thrust | | *Tension in reinforcing steel. | | *Compression in concrete. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ring A. | Ring B. | Ring A. | Ring B. | Ring. A. | Ring. B. | Ring A. | Ring B. |
| Crown | Dead load | — 2,826 | — 2,416 | 24,000 | 25,370 | | | | |
| | Temperature rise | — 5,540 | — 8,108 | 3,600 | 8,123 | | | | |
| | Rib shortening | + 1,385 | + 1,824 | — 900 | — 1,828 | | | | |
| | Total | — 6,981 | — 8,700 | 26,700 | 31,665 | 785 | 1,300 | 418 | 521 |
| Section 10 | Dead load | + 2,430 | + 3,496 | 25,500 | 26,220 | | | | |
| | Temperature rise | + 6,260 | + 9,292 | 3,400 | 7,900 | | | | |
| | Rib shortening | — 1,565 | — 2,095 | — 850 | — 1,782 | | | | |
| | Total | + 7,125 | +10,693 | 28,050 | 32,338 | 112 | 401 | 373 | 371 |
| Section A. A. and Section B. B. (see Fig I.) | Dead load | + 560 | + 2,796 | 25,500 | 26,200 | | | | |
| | Temperature drop | — 7,710 | —12,616 | — 3,340 | — 7,820 | | | | |
| | Rib shortening | — 1,927 | — 2,840 | — 835 | — 1,760 | | | | |
| | Total | — 9,078 | —12,660 | 21,325 | 16,640 | 2,750 | 6,070 | 396 | 386 |
| Point 11 | Dead load | — 4,711 | — 2,476 | 27,750 | 27,650 | | | | |
| | Temperature drop | —13,080 | —29,292 | — 3,270 | — 7,560 | | | | |
| | Rib shortening | — 3,270 | — 6,590 | — 818 | — 1,700 | | | | |
| | Total | —21,061 | —38,358 | 23,662 | 18,390 | 9,050 | 23,000 | 506 | 655 |
| Spring line | Dead load | —23,961 | —30,454 | 29,500 | 30,900 | | | | |
| | Temperature drop | —21,060 | —49,172 | — 3,240 | — 7,460 | | | | |
| | Rib shortening | — 5,265 | —11,080 | — 810 | — 1,680 | | | | |
| | Total | —50,286 | —90,706 | 25,450 | 21,760 | 19,860 | 31,000 | 603 | 631 |

*The stresses in the material were figured on the basis of a "cracked section"—that is, the steel assumed to take the entire tensile stress. In reality such a cracked condition would alter the position of the neutral axis and therefore the pressure curve. However, for our present purpose this method gives a very good indication of the actual comparative stress conditions.

sufficient to more than compensate for the increase due to temperature stresses as above set forth.

In the design of light short span highway arches carrying a spandrel fill ordinary live loading, on the other hand, is very rarely sufficient in amount to materially modify the fibre stresses or the position of the curve of equilibrium. The dead loadings are generally much larger than the live, but do not in many cases induce the determining fibre stresses. Exhaustive experiments to determine the annual internal temperature range in concrete structures typical of those under discussion have recently disclosed a yearly range considerably in excess of that which was formerly generally believed to exist, the effect of which range is to induce stresses which in many cases are the governing factors in the design, and (paradoxical as it may seem), it is nevertheless a fact that in many cases an increase in material in the arch ring proper actually operates to raise the unit fibre stresses due to the combined loadings above mentioned.

It is not the purpose of this article to enter into any mathematical discussion of the above relationships, but rather to submit a comparison of two arch rings illustrating in a vivid manner the extent to which the above facts determine the selection of the economical shape and size of the arch ring.

The two arch rings hereinafter designated as "Ring A" and "Ring B" were recently submitted to the writer for approval. Analysis was made of each ring and the difference in fibre stresses being so noticeable, the intradosal curves were slightly modified so as to exactly superimpose and a comparative analysis made.

The crown depth for both spans is 12 in., varying through a depth of 13 in. at the quarter to a depth of 32 in. at the spring for "Ring A," and varying through a depth of 17 in. at the quarter to a depth of 46 in. at the spring for "Ring B." The comparative analysis has been made for dead load, temperature and rib shortening, the live load being too small to materially change the stress ratios, or increase the fibre stresses. Stresses were computed at the critical points along the ring and a tabulated comparison given in Table I.

A study of the above table, together with the stress sheets of Fig. 1, will reveal the following significant facts:

1. Arch ring "B" contains about 21 per cent more material than arch ring "A," thus increasing the cost for materials and for mixing and placing of concrete in about that ratio.

2. Notwithstanding the above increase in material the average compression in arch ring "B" is about 11½ per cent and the average tension about 90 per cent in excess of the corresponding values in arch ring "A" for the same loadings.

3. The deflection under dead load stress at the crown is .0468 in. for arch ring "A" and .037 in. for arch ring "B." Both these movements being comparatively small, the increased rigidity of arch ring "B" is but a small advantage.

4. The abutment toe pressure for arch ring "B" is 14 per cent in excess of that for arch ring "A" due to the greater value and less inclination of thrust at the springing lines.

It is thus seen that the comparison, both as regards cost and stress condition, is favorable to arch ring "A" wherein the depth of section is not materially increased for the central half of the span. It will be noted that the equilibrium polygon for temperature is a straight horizontal line whose distance below the crown is a fixed quantity for a given arch.[1] Obviously, then, the temperature stress will decrease from crown towards spring line, passing through a zero value at the intersection of the equilibrium polygon with the arch axis and assuming its original or crown value (with opposite sign) at a point symmetrical with the crown with reference to the equilibrium polygon as an axis of symmetry. This latter point may be termed the "equivalent crown point for temperature stress." It is thus apparent that as a provision against temperature no increase in section is needed between the true and equivalent crown points.

Inasmuch as the equilibrium polygon can, by a proper selection of the central portion of the ring, be made to follow the arch axis between these two points, the dead load bending stress may be practically eliminated. The only remaining loading to be taken care of is the live and it can easily be shown that for highway loadings the increase in live load moments between the true and equivalent crown points is so small as to be negligible.

Based not only upon the example given herewith, but also upon the results of a large number of arch rings analyzed in the offices of the Iowa State Highway Commission, we are warranted in the conclusion that—

The economical section for short span highway arch structures of which the span under discussion is typical is obtained when the axial curve is so chosen that the equilibrium polygon for dead loading is practically coincident therewith and when the depth of section between the true and equivalent temperature crown point as defined above is not materially increased.

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[1] Note: This distance, as can easily be shown mathematically, is dependent upon the elastic properties of the ring, and is measured by the quantity:

$$\left[\int_{0}^{\frac{z}{2}} Y\,\frac{ds}{I}\right] \div \left[\int_{0}^{\frac{z}{2}} \frac{ds}{I}\right] \text{ where}$$

"ds" is an infinitesmal increment of axis length, "I" the moment of inertia at any point, and "y" the ordinate to the same measured from a straight horizontal line through the crown.

## AN ECONOMIC COMPARISON OF REINFORCED CONCRETE AND MILL BUILDING CONSTRUCTION.

The two tabulations given present an economic study made by the engineers of the Universal Portland Cement Co. The tables are self-explanatory. In preparing them effort was made to be conservative in all assumptions and to base all interest and depreciation rates on accurate records. In Table I the computations are made on the assumption that the owner rents the building; in Table II on the assumption that the owner occupies the building for his own business.

TABLE I.—COMPARATIVE COSTS OF REINFORCED CONCRETE AND MILL CONSTRUCTED BUILDINGS.
(From standpoint of owner.)
Building 100x175 ft. 7 stories and basement. Total floor area, 140,000 sq. ft.

| | Reinforced concrete (fireproof) | | Mill construction (not fireproof) | |
|---|---|---|---|---|
| First cost of building | $189,000.00 | $1.35 a square foot | $168,000.00 | $1.20 a square foot |
| First cost of sprinkler system | 14,000.00 | | 14,000.00 | |
| Total first investment | $203,000.00 | | $182,000.00 | |
| First investment fireproof more than mill construction, $21,000. | | | | |
| Interest on first investment | 12,180.00 | 6 per cent | $ 10,920.00 | 6 per cent |
| Tax on first investment | 2,030.00 | 1 per cent | 1,820.00 | 1 per cent |
| Depreciation on building | 945.00 | 0.5 per cent | 3,360.00 | 2 per cent |
| Obsolescence | 1,890.00 | 1.0 per cent | 3,360.00 | 2 per cent |
| Depreciation on sprinkler | 1,400.00 | 10 per cent | 1,400.00 | 10 per cent |
| Repairs to building | 472.50 | ¼ per cent | 1,680.00 | 1 per cent. |
| Damage to building by vermin | ...... | None | 200.00 | Estimate low |
| Auxiliary fire equipment | 200.00 | Estimated | 300.00 | Estimated |
| Fire insurance on building | ...... | None required | 235.20 | 14 ct. on $100 |
| | $19,117.50 | | $23,275.20 | |

Yearly expense fireproof less than non-fireproof, $4.157.70.

The yearly saving of $4,157.70, capitalized at 6 per cent, represents $69,295. Therefore, actual cost of concrete building is $119,705, in comparison with one of mill construction costing $168,000.

TABLE II.—COMPARATIVE COSTS OF REINFORCED CONCRETE AND MILL CONSTRUCTED BUILDINGS.
(From standpoint of owner occupying building.)
Building 100x175 ft. 7 stories and basement. Total floor area, 140,000 sq. ft.

| | Reinforced concrete (fireproof) | | Mill construction (not fireproof) | |
|---|---|---|---|---|
| First cost of building | $189,000.00 | $1.35 a square foot | $168,000.00 | $1.20 a square foot |
| First cost of sprinkler system | 14,000.00 | | 14,000.00 | |
| | $203,000.00 | | $182,000.00 | |
| Damage to contents by vermin | 50.00 | | 250.00 | (Estimated) |
| Fire insurance on contents | 650.00 | 26 ct. on $100. (Valuation, $250,000) | 750.00 | 30 ct. on $100. (Valuation, $250,000) |
| | $ 700.00 | | $ 1,000.00 | |
| From Sheet I | 19,117.50 | | 23,275.20 | |
| | $ 19,817.50 | | $ 24,275.20 | |

Yearly expense fireproof less than mill construction, $4,457.70.

Capitalized at 6 per cent, this yearly saving represents $74,295, which can be applied as a mortgage which can be renewed indefinitely, if desired, and it generally is desirable to do this, because most businesses pay better dividends than 6 per cent. Therefore, the actual cost of concrete building is $114,705 in comparison with one of mill construction costing $168,000.

The above figures do not take into account other important items which increase the value of a reinforced concrete building but which cannot be given a definite monetary value. Among these are:

1. Maximum fire protection.
2. Minimum loss by disorganization of business in case of fire.
3. Increased efficiency of workers due to sanitation and better light.
4. Peace of mind of owner and occupant.

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## A $390,000 DRAINAGE PROJECT.

An extensive drainage project has just been brought to the point where bids will be called for in the immediate future. The Chief Engineer is the Edmund T. Perkins Engineering Company, of Chicago and Quincy, Illinois.

The district is situated in the eastern part of Iowa, bordering on the Mississippi River and about ten miles above Fort Madison.

The C., B. & Q. R. R. from Burlington to Fort Madison runs around the northwestern part of the district, at which point is the station of Wever.

The work consists in building the Skunk River Levee, the Mississippi River Levee and Lost Creek Levee and Diversion Channel. In addition are the interior ditches for carrying the surface water to the pumping station located in the southerly part of the district.

The Skunk River Levee consists of a short section of roadway running east and west, with about 12,000 cu. yd. of scraper work, the maximum height being about 7 ft. and decreasing rapidly toward the west. The remaining portion of this levee down almost to the upper end of Peel Slough has a 6-ft. top and side slopes of 3:1 and 2:1. This portion of levee is typical dragline work containing 246,300 cu. yd. Riprap and bank protection will be required for exposed portions of this levee.

The Mississippi River Levee extends from the upper end of Peel Slough to the mouth of Green Bay. The muck ditch will be 5 ft. deep and will be cut through with a small dipper dredge, the material being spoiled. The remaining portion of the levee will be formed by a hydraulic dredge with shutter pipe, material being sand from the Mississippi River. An alternative method would be a California type clamshell dredge. The yardage in the muck ditch is 179,800, and the filling consists of 1,048,000 cu. yd. The maximum height of this levee is 14 ft., a considerable portion of it being 13 ft. The levee will be protected by riprap at the exposed points, for a total of a little more than half its length.

The Lost Creek Levee starts at the mouth of Green Bay and runs in a northerly direction to the point where the natural ground surface is at elevation 535. The yardage amounts to 56,600 cu. yd. and is typical dragline work.

The largest ditch runs from Green Bay to the pumping station for a length of 5,800 ft. with a 30-ft. bottom. The other ditches are all 10 ft. wide on the bottom, with the exception of the upper end of ditch "C."

The bottom elevations of ditch "B" vary from 516 to 511, ditch "C" from 522½ to 517; ditch "D" from 518 to 511; ditch "E" from 519 to 512; ditch "F," 512; ditch "G," 514; ditch "K," 514 to 511. The upper end of ditches "C," "D" and "E" can be done with a dragline if desired.

There are also about five miles of tile drain.

There are 12,000 cu. yd. of scraper work, 432,600 for draglines, 275,750 cu. yd. for small floating dipper dredges and 1,048,000 cu. yd. of hydraulic dredge or clamshell dredge filling, and 67,000 cu. yd. in main "A" which would probably also be done by the dipper dredges, or a total of 1,800,000 cu. yd.

The low tension transmission power line of the Mississippi River Power Co. running to Burlington, parallels the track of the C., B. & Q. R. R. The current is 3-phase, 25-cycles, 11,000 volts. It is proposed to run a permanent line from Wever to the site of the pumping station, at which point the contractor can connect up with his temporary line for the levee on the Mississippi River. A temporary line can also be connected up by the contractor with the main line at Wever for the Skunk River Levee. This is an ideal piece of work for electric machines, as the rates for current will be very low.

## SIX JOBS REQUIRING A TOTAL OF 9,600,000 CU. YD. OF EXCAVATION.

A great deal of excavation work has been placed under contract in the last few days or will come up for letting within two or three weeks. In one mail last week notices were received by Engineering and Contracting of jobs calling for nearly 10,000,000 cu. yd. of excavation. One of them was a contract for the construction of three power dams for the Southern Pacific, the work involving 4,500,000 cu. yd. of excavation and 500,000 cu. yd of concrete. Three others were call for bids notice for levee construction on the Mississippi River, about 2,100,000 cu. yd. of earthwork being involved. The two other jobs were for levee and ditch work for drainage ditches. One of these, on which bids are now being asked, provides for about 1,800,000 cu. yd. of levee and ditch work for a drainage district about 10 miles above Fort Madison, Ia. An outline of the work is given on the preceding page. The other work provides for the repair and reconstruction of about 23 miles of levee on the Mississippi River in the vicinity of Muscatine. Bids on this improvement probably will be asked early in August.

## NEWS LETTERS.

J. A. Ware Const. Co., Houser Bldg., St. Louis. Mo., have some nice team work on the Wabash R. R. in Indiana to let.

The Walsh Const. Co., 1312 Citizens Bldg., Cleveland, Ohio, have 150,000 yd. of good team work at Akron, Ohio, to sublet.

W. S. Helm, 315 Milligan Bldg., Decatur, Ill., have 50,000 yd. of machine work on County road, three miles outside of Decatur, Ill., to sublet.

The Carter Const. Co., St. Louis, Mo., sublet 130,000 yd. of dirt work on the Big Four R. R., near Harrisburg, Ill., to Houser, Tucker & Headley.

The East Side Levee and Sanitary District are going to let contract for approximately 1,600,000 yd of levee work on Monday, July 24th. Will announce the name of the successful bidder in the next issue.

The L. J. Smith Const. Co., 1116 Commerce Bldg., Kansas City, Mo., were awarded the contract for 80 miles of bank and cut widening on the Missouri, Kansas & Texas Railroad between Muskogee and Osage, Okla. They will sublet this in quantities to suit small team outfits. This is all good work and quantities will run from 1,000 to 9,000 yd. approximately. All good material. There is about 1,200 yd. of solid rock and 6,000 yd. of loose rock on the work, all of which is red sand stone. Free transportation to and from work on the M. K. & T. R. R. north of Texas for men and outfits.

A. B. KOENIG.

## PERSONALS.

The John T. Walbridge Engineering Co. has removed its Chicago office to the Tower Bldg.

Arthur E. Owen, heretofore principal assistant engineer of the Central Railroad of New Jersey, has been promoted to Chief Engineer, succeeding the late Joseph O. Osgood.

C. Frank Allen, for the past 30 years a member of the faculty of the Massachusetts Institute of Technology, has resigned his position as Professor of Railroad Engineering.

E. E. Entwisle has been appointed mechanical engineer and placed in charge of all construction work for the mills in the west end of the plant of the Bethlehem Steel Co., at Steelton, Pa.

John H. Cahill, General Contractor, with offices at 1415 Sixth St., Louisville, Ky., has been appointed oil inspector of Jefferson County, Kentucky. This is said to be the most lucrative public office in the state.

Willis Whited, Engineer of Bridges, State Highway Department of Pennsylvania, has received the honorary degree of Doctor of Engineering from the University of Iowa, from which he was graduated in 1879.

G. B. Cortelyou, New York City, has been appointed general manager of the Gulf Cities Gas Co., succeeding W. W. Baltar, Jr., who has been assigned to an important position as sales manager of the business and sales departments.

G. F. Nicholson, District Inspector at the public terminals on the East Waterway at Seattle, Wash., has been appointed acting chief engineer of the Port of Seattle, to succeed J. R. West, who has resigned to accept a position in the University of Pei Yang at Tientsin, China.

Major Harry Burgess, U. S. Corps of Engineers, has been transferred to the Detroit Engineering District, relieving Col. Mason M. Patrick, who has taken command of the Second Battalion of Engineers. Major Burgess for the past 4½ years has been in charge of the Nashville and Tennessee Districts.

A. W. Johnston, of Cleveland, O., heretofore general manager of the New York, Chicago & St Louis R. R., has been appointed assistant to the president. Mr. Johnston was formerly division engineer of the eastern division of the road. Later he became division superintendent and then general superintendent, and in 1906 was made general manager.

G. A. Haggander, heretofore Assistant Bridge Engineer of the Chicago, Burlington & Quincy R. R. lines east of Missouri River, has been promoted to Bridge Engineer, succeeding the late C. H. Cartledge. A. Engh, office engineer of the C., B. & Q., succeeds Mr. Haggander as Assistant Bridge Engineer, and F. H. Cramer becomes office engineer.

Mayor Mitchell of New York City has appointed the following as members of the Board of Standards and Appeal, which is to direct and control building inspection in that city: Rudolph P. Miller, chairman, president of the National Fire Protective Association, compiler of the new building code and formerly superintendent of building in Manhattan; Lansing C. Holding, architect, former director of the New York Chapter, A. I. A.; William Crawford, prominent builder; Howard C. Baird, engineer of wide experience; Alfred R. Kirkus, secretary of the New York Real Estate Association, and largely responsible for the passage of the bill creating this board; and Alfred J. Boulton, representing labor interests.

## OBITUARY.

Caesar Bigler, Agricultural Engineer, and a member of the firm of Bigler, Paul & Furlong, of Sacramento, Cal., died July 11, in that city, from an attack of pneumonia.

Arthur G. Greaves, City Engineer of Sturgeon Bay, Wis., was drowned last week. In addition to being city engineer, he also was manager of the Door County Fruit Growers' Union and secretary of the Door County Fair Association.

Don J. Whittemore, for 47 years chief engineer of the Chicago, Milwaukee & St. Paul Railway, died July 15, at his home, 222 Biddle St., Milwaukee, Wis Mr. Whittemore was born in Milton, Vt., on Dec. 6, 1830, and received his elementary education at Bakersfield Academy. When 17 years old he took the position of chainman with the Vermont & Canada Railroad; two years later he had charge of the division; he next became assistant engineer on the Great Western Railway of Canada While holding this position he went to Ohio to examine some work his father was doing in building the Ohio Central Railroad. On this trip his father was killed and Mr. Whittemore was himself badly injured. He completed the work his father had begun, and then left to accept the position of assistant chief engineer of the La Crosse & Milwaukee Railway. He remained in this position until 1857, and then became engineer of the Southern Minnesota Railroad. During the winter of 1860 to 61 he was chief assistant engineer of the Ferrocarril del Oeste Railway in Cuba. In the spring of 1861 to 1863 he was chief assistant and chief engineer, La Cross & Milwaukee Railroad. In 1863, when this line was merged with the Chicago, Milwaukee & St. Paul Railway, he became chief engineer of the latter railroad and remained in this position until Dec. 6, 1910. He was then appointed consulting engineer to the road. While with the Milwaukee, Mr. Whittemore had charge of the building of many miles of line and supervised the construction of many of the railroad bridges across the Mississippi and Missouri Rivers. He also had full charge of the construction of the Chicago, Milwaukee & Puget Sound Railway, the coast extension of the Milwaukee. He is survived by a widow and one daughter.

## NEW CATALOGS.

**Contractor's Equipment.**—Paper; 3½ in. x 8½ in., 24 pp. Walter A. Zelnicker Supply Co., St. Louis, Mo.

This is the July number of Zelnicker's Bulletin. It lists a large amount of all kinds of contractor's equipment and supplies for sale by the Zelnicker Co.

**Roofing Tiles.**—Paper; 6½ in. x 9½ in., 38 pp. Ludowici-Celadon Co., Chicago, Ill.

This is a concise story of the origin and use of roofing tiles. The book is excellently illustrated by drawings and photographs of various types of buildings, and contains matter of much interest to the architect and builder.

**Ventilators.**—Paper; 4 in. x 8 in., 18 pp. Kernchen Co., Ventilating Engineers, McCormick Bldg., Chicago, Ill.

A bulletin describing the Kernchen Siphonage Ventilator. Illustrations are given of several installations. Results of tests showing the actual cubic feet of pulling power of the different sizes of ventilators are included.

**Wire Rope.**—Paper; 6½ in. x 9½ in.; 18 pp. John A. Roebling's Sons Co., Trenton, N. J.

This is the third number of "Roebling Wire Rope," the technical wire rope bulletin of the John A. Roebling's Sons Company. It contains information on aerial wire rope conveyors, the right and wrong way to measure wire rope, the oldest suspension bridge in America, the Roebling galvanized drop-forged wire rope clip, wire rope practice, incline planes, Roebling wire rope slings and ready reference tables.

**Pneumatic Machinery.**—Paper· 6 in. x 9 in., 124 pp. Ingersoll-Rand Co., 11 Broadway, New York City.

This is a number of "Roebling Wire Rope," the technical the products of the above mentioned company. It covers completely the company's line of air and gas compressors, vacuum pumps, reciprocating and centrifugal water pumps, rock drilling, metal and coal mining, prospecting and quarrying machinery and pneumatic tools for machine and boiler shop and foundry work. In short, this catalog is a complete reference book, which should be of great service to Spanish speaking users of pneumatic machinery.

**Cableways.**—Paper; 9 in. x 12 in.; 18 pp. Lidgerwood Manufacturing Co., 96 Liberty St., New York.

This new bulletin, made up of loose leaves, covers the construction of concrete bridges by cableways. It contains some very interesting illustrations and descriptions of notably large structures in the erection of which the cableways were used. Construction views are shown of the Tunkhannock viaduct of the Delaware, Lackawanna & Western R. R., the Monroe St. bridge at Spokane, Wash.; the Detroit-Superior Ave. high-level bridge at Cleveland, O., and several other bridges. The descriptive matter gives an excellent idea of how the work was handled

## INDUSTRIAL NOTES.

V. A. Stout, Balboa Bldg., San Francisco, Cal., has taken the agency of the Smith Engineering Co., Milwaukee, Wis., to sell the Telsmith Ggratory Crusher.

A. K. Webster has resigned from the drafting and designing department of the Illinois Central R. R. to become sales engineer in the Chicago office of the American Radiator Company.

Reinhard Heeren, heretofore a civil engineer in the bridge and construction department of the Penn Mary Steel Co.'s Steelton plant, has become associated with the engineering and sales department of the Bethlehem Steel Company.

The Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, and Salisbury House, London, England, has established an agency in Holland with Messrs. Petrie & Co., Heerengracht, 141-145 Amsterdam, as its special representatives. Messrs. Petrie & Co. will sell the Sullivan air compressors, rock drills, hammer drills, diamond core drills, quarrying and coal mining machinery in the Netherlands. This new arrangement replaces the Sullivan Machinery Company agency previously at the Hague.

Among the contracts recently awarded to the Raymond Concrete Pile Co., New York and Chicago, are the following: Concrete piles for the foundation of a retaining wall for the Barrett Mfg. Co., Cleveland, O. J. F. Miller, Engineer for the Barrett Co. Concrete piling foundation in building for American Hard Rubber Co., East Akron, O. Walter Kidde, Engr. Concrete piles for St. Thomas's School, Brooklyn, N. Y., for which Frank J. Helmle is architect. Concrete piles in foundations for the Mohegan Tube Co., Maspeth, L. I. J. L. Sussman, Engr. Concrete piles in the foundation of a fabricating shop for the Bethlehem Steel Co., Sparrows Point, Md. Concrete piling for stack foundation for the P. C. C. & St. L. Ry., Columbus, Ohio. Two thousand Raymond piles for Open Hearth Furnace foundations for the Corrigan-McKinney Co., Cleveland, O. H. T. Harrison, Chief Engineer.

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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## THE $75,000,000 FEDERAL-AID ROAD BILL SIGNED BY WILSON.

After more than a decade of vigorous effort, the federal government has been persuaded to aid the states in building roads. President Wilson has signed a bill appropriating $75,000,000 for federal-aid highways. In our July 5 issue we outlined the terms under which each of the states is to receive its share of the appropriation.

Of the 48 states, all save Texas, Indiana, Georgia and South Carolina have state highway departments. Since these four states will be entitled to $9,816,000 of the $75,000,000, it is likely that none of them will long delay the centralization of their highway systems.

To receive its share of the federal appropriation, every state must appropriate a sum equal to that assigned to it from the federal purse. Beyond question, then, the combined appropriations of the states and the federal government will be $150,000,000 for roads, in addition to the ordinary expenditures for highway work.

Huge as this sum is, it has been estimated that ten times $150,000,000 will be expended for American road construction during the next five years. We are inclined to doubt whether as much as $300,000,000 a year will be invested in roads before the close of the ensuing five-year period, but we believe that by the end of 1920 the country will have reached that rate of road expenditure.

It has been said that Ford is planning to manufacture 1,000,000 cars annually, which would alone exceed in value the highest estimates of annual investment in improved roads. The ratio of investment in railway rolling stock to railway roadbed, etc., is about one to five. While it is not probable that, for a long time to come, the investment in motor cars and trucks will be anywhere near as low as one-fifth the investment in roads, still it is certain that capital invested in roads must eventually exceed many times the capital invested in motor cars and trucks.

There are about 2,500,000 motor vehicles in America, the investment in which is approximately $2,500,000,000. In our issue of Sept. 18, 1912, we gave our estimate of the cost of reproducing all the roads of America, as of the year 1909, and it was $2,700,000,000, of which only about 20 per cent was invested in "hard roads." If to the investment in motor vehicles we add the investment in wagons, horses and mules used on roads, it is evident that we shall have a grand total well in excess of the entire cost of reproducing all the country roads in America.

We believe that it will prove economic to maintain a ratio of investment in roads to investment in road rolling stock that will be fully three to one. Therefore, in spite of the accelerating pace at which road building is progressing, a vast deal remains yet to be done before road building appropriations shall be ample.

The investment in American railways is more than six times the investment in roads. In a properly designed highway system the investment in roads should not be less than the investment in railways. To bring about this result America would have to spend $1,500,000,000 a year during the next ten years, even assuming no growth whatever in railway investment. Yet the late James J. Hill said ten years ago that to keep abreast of the economic demands more than $1,000,000,000 should be annually invested in additional railway facilities.

For every mile of railway there are ten miles of roads. The investment in a mile of railway averages about $60,000. If the investments in both were equal, it would follow that there would be about $6,000 invested in the average mile of road. At present this will seem like an extravagantly high average, but in a few years the general use of motor cars and trucks will make it seem low rather than high. Undoubtedly the general use of motor vehicles will bring about a widening of all main roadways and a thickening of the pavements to uphold the great wheel loads of trucks. Since a narrow, thinly paved road now costs about $12,000 a mile, we must look to see investments of fully $20,000 a mile in the main traveled roads. Of course the cost of most of the "branch roads" will not be more than one-tenth to one-quarter this sum.

A total of twenty-odd billion dollars in roads is to be looked for before many years, and, contrary to the opinions of those who decry road bond issues, it will pay the country richly to make such an investment.

## DURATION OF CLOSURE TO TRAFFIC OF CONCRETE ROADS.

Few demands on the concrete road builder are more urgent than the call of traffic for a quick opening of the road. Indelible evidence is furnished by too many concrete roads either that road officials are over lenient to the demands of traffic or that their barriers have been forced by traffic. One cannot travel far on almost any concrete road without seeing the marks of wheels in its surface, or the prints of horse's hoofs or the cuts of corrugated wheels of tractors. Each mark is proof that the road was opened to traffic too soon after construction. Each rut and depression is a lesion for the attack of traffic. Wear begins at irregularities. None of these facts are unfamiliar to the experienced concrete road builder and no concrete road builder is so unfamiliar with concrete as not to know when it can safely bear traffic. Prints of traffic in a concrete road surface indicate only one thing, which is carelessness. Either the engineer has taken a chance with his concrete or his watch on the work has not been close enough to prevent trespass. The specifications are only rarely at fault, unless it be a fault that they stipulate arbitrary periods of closure to traffic instead of basing the time on direct test. Why not adopt a magnified Vicat or Gillmore needle test for concrete roads to determine when traffic shall be admitted to them? Concrete roads become hard enough to bear traffic in varying periods of time depending upon a number of conditions. Occasionally seven days is ample time, more often two weeks are required and in rare cases safety is certain only after three or four weeks. Why not determine the matter by test and not leave it to a numeral in the specifications?

## "COMPARING INCOMPARABLES" IN RATING THE ANNUAL COSTS OF VARIOUS IMPROVEMENTS.

We reprint elsewhere a letter from Mr. Philip P. Sharples, in which he criticises a table of annual unit costs of various pavements published in our last Road and Street Monthly issue, July 5. The author of the table is Mr. Eugene W. Stern, Chief Engineer of Highways, Borough of Manhattan, New York City.

Mr. Sharples speaks of the table as one in which the attempt is made to compare incomparables. And, as the bare table stands, it is undoubtedly true that it does cause a comparison of unit annual costs that are strictly not comparable. It may be replied, however, that the text accompanying the table indicates that the "figures given are believed to be not above the average" for the "country district immediately about New York City." To which we would reply by asking two questions:

Is it logical to use average figures where no individual roadway, save by chance, corresponds to the average conditions?

What are the actual data upon which the lives and repair costs of the various types of pavements are based?

It needs no extended argument to demonstrate that "average costs" have little value save where applied to "average conditions." Nor does it need proof to establish the self-evident fact that every road differs from every other road as to density and character of traffic, to mention only two of the conditions. The life of a pavement is determined by six principal factors: (1) Effect of natural forces, such as chemical action; (2) traffic character; (3) traffic density; (4) character and extent of upkeep; (5) improvements in the art; and (6) changes in the taste of those who control public policy as to highways.

Mr. Stern, in common with most highway engineers, assumes an "average life" of about 20 years for most classes of paving surfaces. But where are the data to sustain the assumption of such an "average life"? And, having produced the data for the "average," where are the data as to the effects of the various factors upon the life of a pavement that is not of the "average"? We have repeatedly asked these questions in times past, yet the answer remains as ever the same: "I speak from my general experience when I give my estimates of average life of pavements."

As scientific men we have a right to cross-examine any engineer who gives only a general answer of this sort. "General experience" is too often a cloak for individual as well as general ignorance. Judged by the meagerness of published data as to actual lives of individual road pavements, we are all, in about the same degree, ignorant of the life of different pavements under given conditions.

Our knowledge of annual repair costs is somewhat more satisfactory, yet far from what it should be. For most of the types of pavement used in his estimates Mr. Stern assumes annual repairs to average 2 ct. per sq. yd. per annum. Thus he uses this 2-ct. average for the following pavements: Concrete, sheet asphalt, brick and wood block. For asphalt block he assumes 3 ct., for granite block 1 ct., for asphaltic concrete 2.35 ct., for bituminous macadam 12 ct., and for waterbound macadam 15 ct. On the face of it, there is no probability that under the same traffic conditions concrete, sheet asphalt, brick and wood block would all show the same annual repair costs. And it is even more improbable that they would all show practically the same length of life—20 to 25 years—under the same conditions. If the conditions are not the same for all, then Mr. Sharples is entirely right in saying that "nothing is gained by comparing incomparables."

We trust that our criticism will not be taken as being at all aimed at Mr. Stern or any other individual who has attempted similar comparisons of annual unit costs of pavements, for the fact is that adequate data are so completely lacking that no engineer can make more than a rough estimate of the unit annual costs of different pavements. The crying need is for data that are in such form as to be comparable.

## LOCATION AND DESIGN OF ROADS AT RAILWAY CROSSINGS.

Mr. H. E. Bilger has suggested the desirability of so locating a road that at railway crossings a clear view of the track may be had for fully 1,000 ft. each way from the crossing, and that this view may be had from any point on the road within 300 ft. of the crossing. He also advocates an easy grade at the crossing, not more than 2 per cent for 50 ft. each way, and a roadway never less than 18 ft. wide.

There are many grade crossings located in deep cuts or obscured by vegetation that are vertiable death traps. One of the first steps in any comprehensive planning of a state road system should be the elimination of all such crossings, either by an entire relocation or by regrading and clearing.

## CONSISTENCY OF CONCRETE FOR ROAD CONSTRUCTION.

On a succeeding page is given pictorial definition on the authority of the Bureau of Standards of quaking, mushy and fluid concrete mixtures. At the Second National Conference on Concrete Road Building the Committee on Proportions and Consistency of Concrete stated: "The consistency of concrete for road or street work should be such that when deposited from a chute or bucket it will settle in a flat mass, but will not flow on the subgrade." The picture of the Bureau of Standards of fluid concrete meets very closely the requirements of the committee's statement. Also the tests of the Bureau show that of the three mixtures, quaking, mushy and fluid, the last almost invariably gives concrete of least compressive strength.

The question of concrete consistency is prominent at the present moment in concrete road construction. From every direction comes evidence that engineers are experiencing a revulsion against wet concrete. It is more than probable, judging from past experience with such revolutions of feeling, that the swing will be too far toward parsimony in the use of water. The concrete road builder should not forget to guard against this danger. There are very good reasons why wet mixtures have become popular. A wet concrete is more rapidly mixed, it flows better in distributing chutes, it requires less spreading, it is more easily screeded and floated to surface. In a sentence, less labor is required to produce a finished slab of pavement. It also demands less watchfulness to ensure the perfect curing of this slab if a wet concrete is used. These are important advantages not to be lightly cast aside on the evidence of laboratory compressive strength tests. No one will deprecate the importance of strength, and particularly strength of resistance to abrasion in concrete for pavement, but are we certain of its complete precedence to all other properties?

One merit of concrete compared with other hard paving materials is its low cost. This low cost is due in no small measure to the use of wet mixtures. Should we risk this advantage to gain the greater strength promised by dry mixtures? Just how important is the element compressive strength in concrete for pavement? Strength of pavement slab can be obtained by increasing the volume of concrete in the slab as well as by increasing the unit strength of the concrete. Which is the cheaper method? An article in this issue shows that the wearing strength of a concrete pavement is dependent on many factors besides compressive strength of concrete. Would not effort applied to some of these other factors profit us more than to seek too persistently after the greater compressive strength of dry mixtures?

## THE USE OF ROAD GRADERS AND HARROWS FOR MIXING THE INGREDIENTS OF A GRAVEL ROAD.

In the best types of gravel roads it is now customary to secure a proper relation between the amount of pebbles and the amount of binding material—loam or clay. Even when natural bank gravel has just the right percentage of binder to fill the voids in the pebbles, the binder is seldom distributed uniformly. Moreover, the hauling and dumping tends to segregate the binder from the pebbles.

To mix the ingredients, whether from a natural bank or from an artificial combination, is very important.

Mixing is best accomplished by the combined use of harrows and road graders. After dumping the gravel in piles, spread it with the blade of a road grader, harrow it to break up any "cores" or consolidated spots, and then give it a thorough mixing by casting it from side to side with the blade of the grader. This latter process is one with which relatively few road builders are familiar, but it is one that the editor has used for mixing gravel, sand-clay and petrolithic (earth or gravel with road oil) roads. The road machine is so manipulated as to throw winrows of gravel from the center to the side of the road, scraping off the gravel almost down to the subgrade. Then the winrow thus piled along the sides is cast back into the center. About four trips of the road grader over each strip of gravel 6 ft. wide will serve to secure a thorough mixture of the ingredients.

If the natural mixture of ingredients is fairly good, a harrow alone may suffice to perfect the mixture. Mr. H. E. Bilger recommends a harrow having teeth about 1 in. diameter by 6 in. long, with a weight of 8 to 12 lb. on each tooth. Upon the harrowed and level course of gravel he spreads the necessary amount of bonding clay, which is harrowed into the gravel. The editor goes one step farther in recommending the use of a grading machine, as above indicated, for securing a very thorough mixture; for the tendency of harrowing is to bring the larger pebbles to the top, which can be most effectively overcome by turning over the moss with the blade of the road grader.

## CONCAVE PAVEMENT "CROWNS" IN THROUGH CUTS AND ON VILLAGE STREETS.

The convex or crowned pavement is so universally regarded as preferable to a flat or concave surface that it requires some courage to depart from the convex cross-section. There are conditions, nevertheless, where the standard convex surface should be departed from.

In "through cut," particularly on steep grades, a concave cross-section is usually to be preferred, provided the maximum rain run-off can be carried in the paved part of the road and provided the surface of the road is such that flowing water will not injure it. Paved side ditches are thus eliminated, and with their elimination comes not only a decreased first cost, but a decreased maintenance cost. Experienced road engineers know how difficult it is to maintain even a paved side ditch on a steep grade. The run-off water insists on cutting its way alongside or beneath the ditch paving.

In village streets a concave pavement permits the elimination of curbs and the substitution of sodded shoulders on the sides of the pavement.

Water flowing in the center of a roadway is, of course, objectionable if the road surface is of a sort that is injured thereby, but few of the modern types of surface are thus injured.

## A WORD OF COMMENDATION.

To the Editors: Your paper certainly has greatly improved in appearance, arrangement, printing and illustrations. The book notices are excellent. The "Lighter Side" is in better form now and to be read first, to forget my worries and smile. You have my congratulations on producing a technical paper, a credit to Chicago and the Great West.

Yours very truly, Chas. H. Bell.
Buenos Aires, Argentina, May 9, 1916.

## REVIEW ARTICLES APPRECIATED.

To the Editors: I have noticed of late a tendency on the part of the editors of Engineering and Contracting to publish articles of a general nature on several of the phases of engineering work. About two weeks ago there was an excellent article about measuring the flow of water and in this last issue there was an excellent article on the disposal of sewage by Mr. H. P. Eddy. I think such articles are of great value as they give the young engineer a chance to get information on certain phases of engineering work without its being necessary for him to wade through a large amount of data. Such articles treated in a general way give the young engineer a basis to work on, and if he is interested he can study the details further. I hope you will find it possible to publish many more articles of this nature.

Yours very truly,
Philip W. Taylor,
Assistant Engineer Sewage Disposal Commissioners.
Fitchburg, Mass., June 30, 1916.

## COMPARATIVE COSTS OF PAVEMENTS.

To the Editors: I note article in the July 5 number on "Comparative Cost of Various Types of Pavement," taken from a paper by Mr. Eugene W. Stern, presented at the Second National Conference on Concrete Road Building.

This paper contains a fallacy which it seems to me should not be left unnoticed. In making up the comparative cost of different pavements, the cost of the concrete pavement is reduced by deducting the value of the concrete pavement as a foundation. Arguing from the same standpoint, there is absolutely no reason why in the cost of the other pavements, the value of these pavements or the value of the foundation should not be deducted in every case. Certainly, waterbound macadam has been very successfully used as foundations for fairly expensive toppings, as in Dartmouth St., Boston; and bituminous macadam has also been used in the same way as may be seen on Massachusetts Ave., Cambridge, where wood-block was laid over a foundation prepared for bituminous macadam. It might even be said in this case that the macadam was worth as much as the concrete base, and that there was 13 ct. credit due to the macadam in addition to the entire cost of the orignal macadam, to make it compare with the concrete.

Such corrections as these would put an entirely different face on the table prepared.

I also do not think it fair to say that a concrete pavement has a useful life of 20 years before requiring a surfacing coat. Certainly, when subjected to a traffic similar to that taken by a granite block or sheet asphalt pavement, with which it is compared, it would not last 20 years, but probably nearer 2 years before the retopping was required.

In Cambridge, on Massachusetts Ave., a concrete pavement subjected to very heavy traffic was so far gone in 5 years, that it was impossible to repair it, and it was used, after extensive repair as a foundation for a bituminous top. To have kept the street in satisfactory condition, this fate should have come to the concrete pavement at the end of two years.

Such tables as Mr. Stern has prepared are extremely useful, but I believe nothing is gained by comparing incomparables.

Yours very truly,
Philip P. Sharples.
New York, N. Y., July 13, 1916.

[Mr. Stern would undoubtedly reply to the criticism of Mr. Sharples by pointing out that in his estimates he assumed that a 6-in. concrete base costs only 80 ct. per sq. yd., whereas a 6-in. concrete pavement costs $1.12 per sq. yd., the difference in cost, 32 ct., being due to the larger percentage of cement required to make a concrete surface stand up under the direct impact of wheels and hoofs. Hence to amortize this 32 ct. over the assumed 20-year life of the surface is a proper charge. In this conclusion we agree, if we grant the assumed life and assumed unit costs.

Mr. Sharples states that waterbound macadam can also be used as a foundation for block and sheet asphalt. This is true, but Mr. Sterns has virtually assumed a perpetual life for the macadam, and he indicates that this can be secured by the expenditure of 15 ct. per sq. yd. on annual repairs. We believe that long before any such high average cost of maintenance is reached it is economic to surface the macadam with some more durable wearing coat, and that, therefore, Mr. Sharples is sound in his criticism.

That Mr. Stern has virtually "compared incomparables" is also a valid objection upon which we have editorially commented elsewhere in this issue.—Editors.]

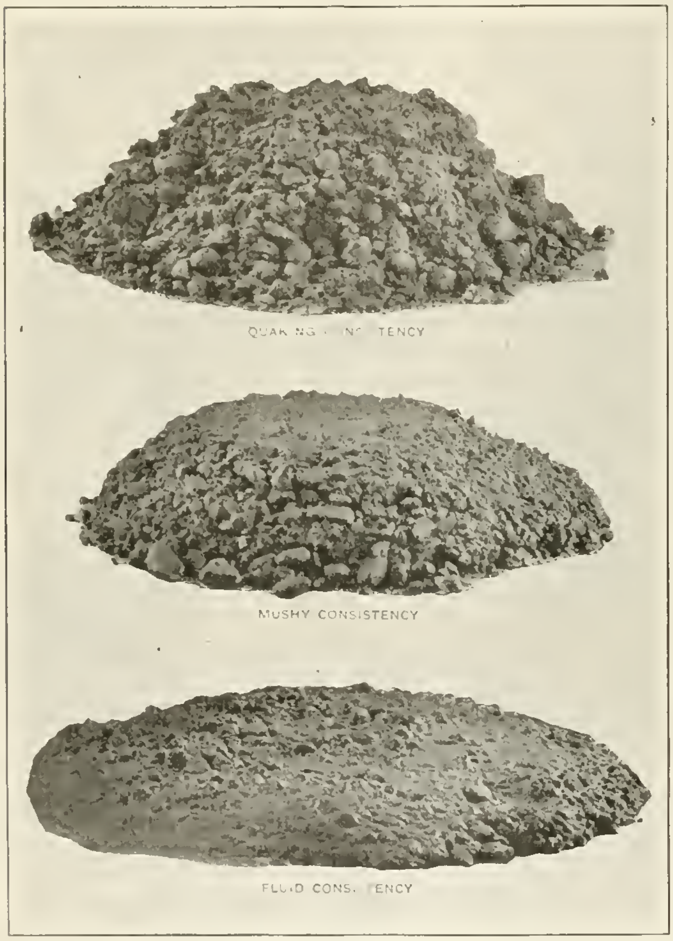
## APPEARANCE OF QUAKING, MUSHY AND FLUID CONCRETE.

In tests of concrete by the Bureau of Standards six consistencies of concrete were employed. They were defined as follows:

Dry.—Containing just sufficient water to cause the cement and sand to adhere after tamping and removal of the molds.

Moist.—A mean between the "dry" and "plastic" consistencies.

Plastic.—Containing the maximum quantity of water which allows the removal of the forms immediately after molding. The surface of the mass shows weblike marks of neat cement and water.



Views of Quaking, Mushy and Fluid Concrete.

Quaking.—A stiff mixture upon which water can be brought to the surface by slight tamping. The mass should not flow readily.

Mushy.—A soft mushy mixture which is not watery, but can be spaded and readily worked into place in the form.

Fluid.—A watery mixture which flows readily into place in the form with little or no working.

A photograph of three batches of concrete to illustrate the three consistencies, "quaking," "mushy," and "fluid," is shown in Fig. 1. In forming each of the piles the concrete was allowed to slide from the shovel and drop only a few inches onto the pile, the weight causing the material to spread out and take the shapes shown. Dumping from a barrow or allowing the mixtures to flow from a chute would have caused the materials to spread further and form flatter cones, which would give the appearance of wetter consistencies than the method which was used.

The difference in appearance of the dry, moist, and plastic mortars is not sufficient to be illustrated by photograph, and can best be determined and measured by squeezing a mass in the hand.

## SCARCITY OF LABOR AFFECTS HIGHWAY BIDDING.

Scarcity of labor is having a marked effect in reducing the bidding competition on state highway work in New York. In other states, also, there has been a noticeable reduction in the number of bidders at recent road lettings. The State Highway Commission of Ohio opened bids July 20 on 22 contracts. On four of these no bids were received, while on the others the number of bidders was far less than at previous lettings. In Pennsylvania, also, there has been no especial brick competition for state road jobs. On July 19 the State Highway Department opened proposals for six contracts. On one of these, covering about 5 miles of highway, 9 bids were received. On two contracts there were five bidders on each; on two other contracts there were three bidders, and one contract, a $150,000 job, there were only two bidders.

In New York state, however, the lack of competition has been especially marked. At the lettings of July 10 and July 14, on several contracts no bids were received, while on others only one contractor submitted proposals. The greatest number of bidders on any one job was five. The following tabulation gives some details of the lettings:

LETTING JULY 10.

| No. | County. | Miles. | No. bidders. | Low bid. | High bid. |
|---|---|---|---|---|---|
| 948A | Albany | .17 | 2 | $ 2,212 | $ 2,332 |
| 1371 | Albany | .88 | 4 | 26,562 | 27,515 |
| 5610 | Cattaraugus | 4.39 | 2 | 66,365 | 74,630 |
| 1027 | Chautauqua | 4.33 | 3 | 61,473 | 70,583 |
| 1378 | Chemung | 4.14 | 4 | 99,195 | 102,239 |
| 1394 | Chenango | 7.09 | 3 | 90,429 | 92,219 |
| 1398 | Clinton | 10.46 | 1 | 111,888 | ...... |
| 1412 | Dutchess | .56 | 2 | 8,071 | 8,116 |
| 1410 | Essex | 1.76 | 1 | 24,163 | ...... |
| 620 | Fulton | 5.13 | 2 | 49,044 | 65,987 |
| 1365 | Greene | 2.39 | 3 | 26,620 | 30,520 |
| 1346 | Herkimer | 5.10 | 4 | 66,449 | 93,449 |
| 1360 | Madison | 6.54 | 1 | 64,673 | ...... |
| 1390 | Monroe | 2.92 | 3 | 36,955 | 41,766 |
| 1342 | Nassau | 5.24 | 5 | 84,480 | 96,556 |
| 1355 | Oneida | 5.24 | 1 | 76,252 | ...... |
| 1408 | Otsego | 8.13 | 4 | 88,569 | 101,372 |
| 1117 | Saratoga | 6.10 | 3 | 79,254 | 88,900 |
| 1406 | Wayne | 3.67 | 5 | 35,000 | 36,461 |
| | LETTING JULY 14. | | | | |
| 1405 | Albany | 2.93 | 4 | $ 35,875 | $ 40,222 |
| 1380 | Chautauqua | 5.65 | 3 | 123,126 | 134,096 |
| 1156 | Chenango | .82 | 4 | 15,414 | 18,536 |
| 1376 | Fulton | 2.8 | 1 | 45,834 | ...... |
| 1377 | Fulton | -3.74 | 1 | 40,609 | ...... |
| 1403 | Genesee | 7.94 | 5 | 90,091 | 98,286 |
| 1363 | Herkimer | 5.67 | 2 | 56,909 | 68,363 |
| 1374 | Madison | .91 | 3 | 11,651 | 12,358 |
| 1392 | Monroe | 3.69 | 1 | 38,844 | ...... |
| 1393 | Monroe | 5.27 | 2 | 62,500 | 63,984 |
| 1354 | Oswego | 5.55 | 4 | 65,602 | 68,745 |
| 1413 | Onondaga | 2.04 | 4 | 23,165 | 28,277 |
| 1409 | Otsego | 7.87 | 3 | 124,673 | 132,445 |
| 1388 | St. Lawrence | 11.16 | 4 | 99,239 | 109,197 |
| 5612 | St. Lawrence | 9.12 | 1 | 144,784 | ...... |
| 1373 | Ulster | 2.73 | 3 | 39,651 | 51,416 |
| 1059 | Wayne | 1.88 | 2 | 15,128 | 15,707 |
| 1060 | Wayne | 6.41 | 6 | 56,987 | 69,230 |

In New York state this condition is somewhat unusual. Regarding this Mr. H. S. Breed, First Deputy Highway Commissioner, advises as follows:

"The main reason for the contractors not bidding seems to be because of the scarcity of labor. Many of them have signified a willingness to take contract work but for that particular phase of the situation. Most of our contractors have about enough work now to keep their permanent organization busy, and until conditions become more stable will not branch out and take extra work as they would do in normal times. On much of our work the prevailing rate for labor is higher than it has been at any time within my recollection, and even at the high rate being paid now, it is impossible for contractors to get men."

## ANCHORING CURB TO ROAD PAVEMENT.

In the construction of 3½ miles of concrete road in the village of Ojibway, Ont., the following method was used for anchoring the curb to the pavement: The road was poured first and lengths of ⅝-in. Kahn rib bars set upright along the curb line. The curb was then poured on top of the road, the rib bars at intervals extending up into the curb and thoroughly anchoring it to the road.

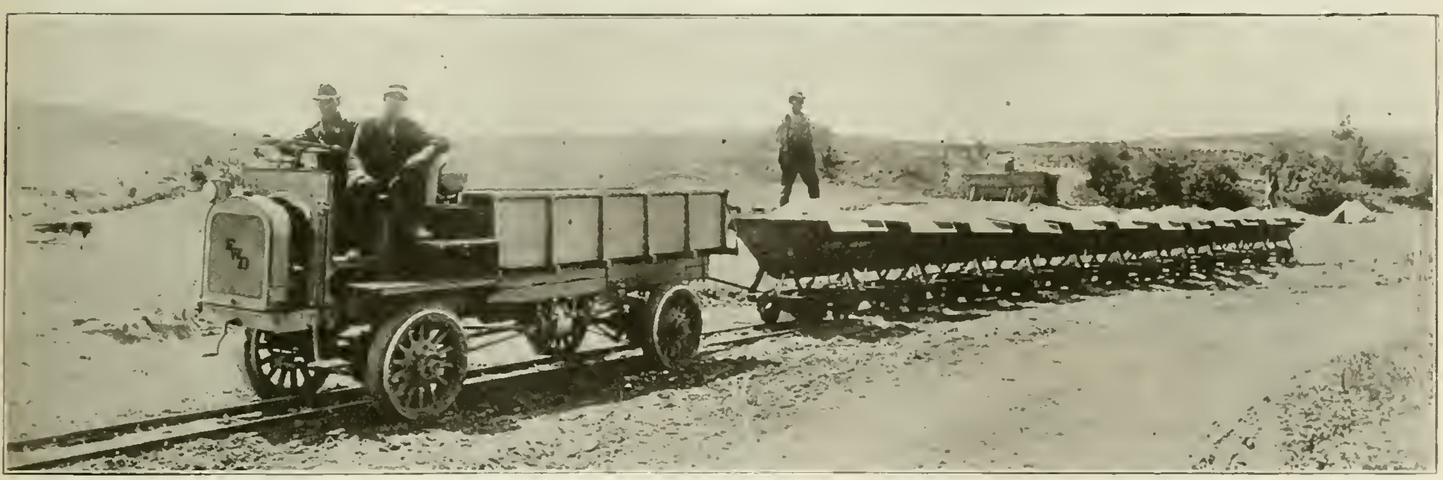
## COLOR SCHEME FOR DESIGNATING HIGHWAY ROUTES.

The county officials of Crook County, Oregon, have adopted the following scheme for the designation of highway routes through the county: The telegraph poles, fences, bridges, etc., are marked with different colors on a white background, each color denoting a particular route. Seven routes have been selected for the initiation of the system. The color to correspond with these are light blue, dark blue, red, yellow, orange, green and maroon. Where two routes cross or run along the same road, the colors of both routes are painted on the same pole, one above the other. The turns to the left and to the right are denoted by the painting of a large "L" or "R" in a large square in the same color as that used for the route.

## MOTOR TRUCK FOR HAULING INDUSTRIAL RAILWAY CARS IN ROAD CONSTRUCTION.

(Contributed.)

A very interesting and unusual use of the motor truck is illustrated by the accompanying illustration. This Four Wheel Drive truck, in the service of the Hanlon & Oakes Co., contractors, of Sioux City, Ia., is used in place of a locomtive to draw a train of heavily loaded trailers on a narrow gage track. The truck itself straddles the rails, and it is interesting to note that enough traction is secured to pull the train easily up a 5 per cent grade, although no load whatever is carried on the body of the truck.



Three-Ton Four-Wheel Drive Truck Hauling Industrial Railway Cars for Road Work in Iowa.

The crushed rock, gravel and cement hauled by this outfit are being used in the construction of a 16-ft. concrete highway going north from Sioux City on what is known as the Perry Creek road. The large amount of material hauled is indicated by the fact that from 500 to 600 lin. ft. of pavement are being laid daily. The track is four miles in length and ten round trips are made each day. Each trailer carries 1½ cu. yd. of gravel or crushed rock, making a total pay-load of 24 to 26 tons. The truck pulls this load while running in high gear, and travels at 12 to 15 miles per hour.

Fifty teams and wagons were unable to do the work which is now being done by this truck and string of trailers, according to the contractors, and an enormous saving in cost is effected. The average daily cost of operating the truck and trailers in this service is $17.

## COST OF APPLYING BITUMINOUS SURFACE TO MACADAM ROAD.

The following data on the cost of applying a bituminous surface on a macadam road are taken from the May Illinois Highways, the official publication of the State Highway Department. The figures do not include contractor's profits nor overhead expense. The road was located in Blairsville Township, Williamson County.

### GENERAL CONDITIONS.

Total length of road treated, 12,022 ft.; total square yards of road treated, 16,029 sq. yds.; condition of old macadam road, fair, generally, one place poor; kind of bituminous material used "Tarvia B"; amount of bituminous material used ½ gal. per square yard; amount of sand 1 cu. yd. per 200 sq. yd. of surface; average length of haul on materials, 1 mile; general condition of weather, good; rate of pay for labor, 22½ ct. per hour; teams, 40 ct. per hour.

### ITEMIZED COST OF WORK.

| | Total cost. | Cost per sq. yd. |
|---|---|---|
| Engineering and inspection | *...... | ...... |
| Superintendence, salary and expenses | $104.22 | $0.0065 |
| Bituminous material, 8,000 gal. @ $0.05 f. o. b. siding. | 400.00 | .0250 |
| Torpedo gravel and sand, 80 cu. yd. @ $1.23 f. o. b. siding | 98.59 | .0061 |
| Hauling bituminous material | ...... | ..... |
| Hauling torpedo gravel and sand | 56.83 | .0035 |
| Heating and applying bituminous material, demurrage, etc. | 93.35 | .0058 |
| Spreading gravel and sand | 23.85 | .0014 |
| Sweeping and cleaning old road | 8.40 | .0005 |
| Depreciation on equipment | *...... | ..... |
| Freight on equipment | 36.68 | .0023 |
| Incidental expense | 7.95 | .0005 |
| Total cost | $829.87 | $0.0516 |

*Indicates paid or furnished by the State Highway Department.

## A 34-YEAR-OLD BELGIAN BLOCK PAVEMENT.

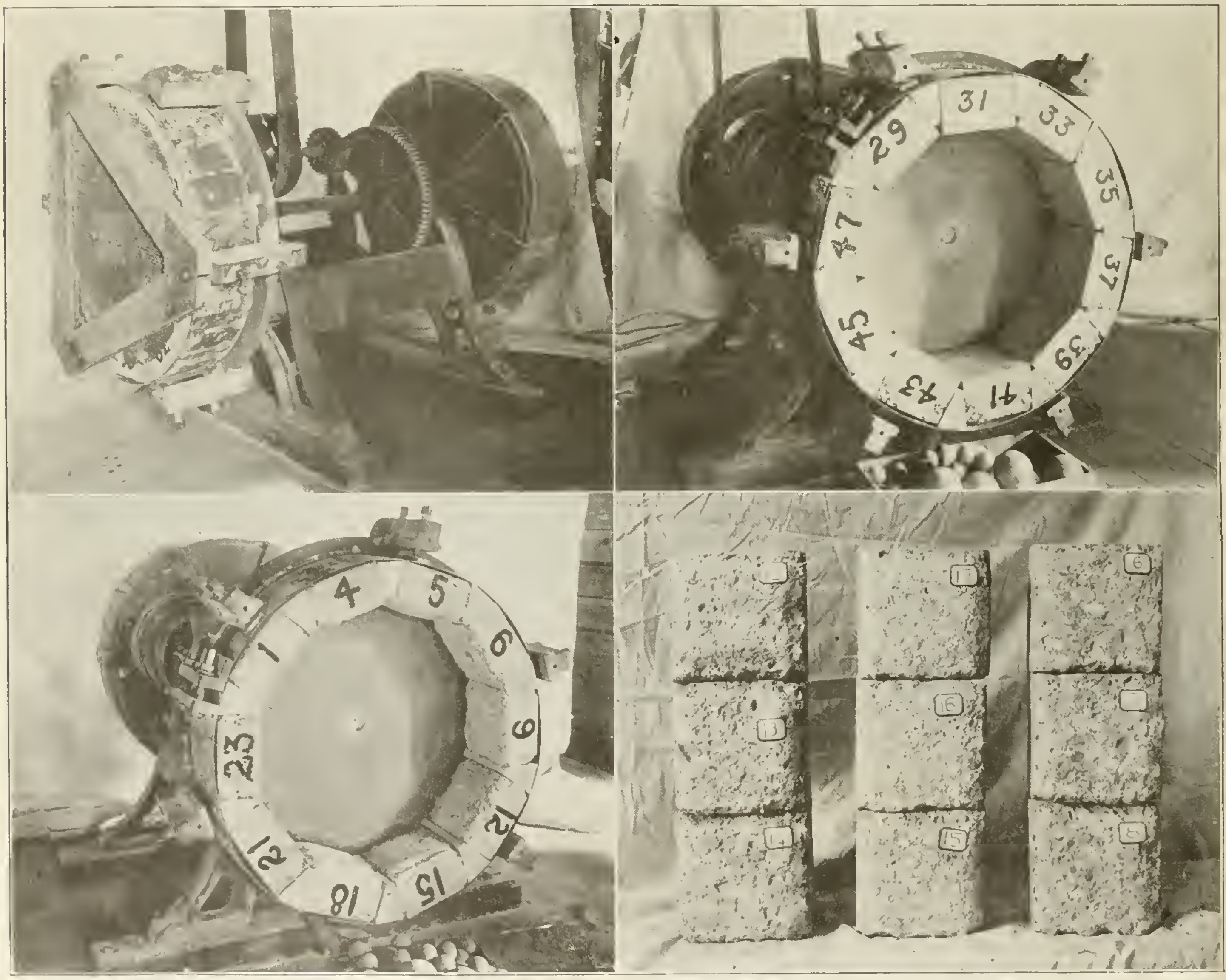
The first Belgian block pavement in the city of Atlanta, Ga., was laid on Alabama Ave., between Central Ave. and Madison Ave., in 1882. The blocks were split only, not reeled nor trimmed. They were approximately 6 in. to 12 in. in length, 4 in. to 6 in. in width and 5 in. to 8 in. in depth. They were laid on sand and sand cushions without particular care being taken as to the selection of uniform width blocks for individual courses. Most of the orginal granite block pavements were from weathered and partially disintegrated surface stones. The average cost to the city of the Alabama St. pavement was $2.25 per square yard. In a paper in the June proceedings of the Engineering Association of the South A. P. McClellan states that the original pavement has been in service for 34 years at a cost of 6.6 cts. per yard year. Repairs chargeable directly to the wearing of the pavement during this entire time have been partially negligible.

## PREVENTING BURROWING OF MUSKRATS IN ROAD GRADES.

Much damage has been caused to road grades in Western Minnesota by muskrats burrowing into the earth for the purpose of establishing homes and rearing their young. The June Minnesota Highway Journal states that in Hennepin County it was found that the damage caused by muskrats could be minimized by placing three or four lengths of 6-in. tile at the location where rats burrowed into the ground and allowing them to use the tile for a nesting place.

## WEAR TESTS OF CONCRETE FOR ROAD CONSTRUCTION.*

Tests of the wearing resistance of concrete are being made, using a Talbott-Jones rattler. The machine is shown in Fig. 1. The test pieces consist of blocks 8 in. square and 5 in. in thickness. The blocks are arranged around the perimeter of the drum of the rattler as shown in the accompanying illustrations. Ten blocks constitute a test set. The concrete test pieces are separated by wedge-shaped wood blocks. The ten-side polygon formed by the test blocks presents a nearly continuous inner surface, as shown in Fig. 2. The outside diameter of the polygon thus formed is 36 in., and the inside diameter 26 in. During the test the front of the chamber is closed by means of a heavy wire screen.



TALBATT-JONES RATTLER. VIEW OF BLOCKS BEFORE TEST. VIEW OF BLOCKS AFTER TEST. VIEW OF TESTED BLOCKS.
Blocks 6, 7 and 8 Are 1½:2½ Gravel; 12, 13 and 14 Are 1:2:3 Gravel; 15, 16 and 17 Are 1:2:3 Limestone.

The abrasive charge consists of 200 lb. of cast iron spheres—about 133 spheres 1⅞ in. and 10 spheres 3¾ in. in diameter. These spheres conform to the specifications for spheres for use in the standard rattler test of paving brick. The test consists of exposing the inner faces of the concrete blocks to the wearing action of the charge of cast iron spheres for 3,600 revolutions at the rate of about 30 r. p. m. Best results have been obtained by reversing the direction of the machine two or three times during the test. Each block is weighed immediately before and immediately after the test. The loss in weight is considered to be the wear. This loss may be reduced to a percentage of the original weight, or it may be expressed as depth of wear in inches. In comparing concretes of widely different characteristics, or in comparing concrete with other materials, the latter method is preferable.

**Results of Tests.**—About 200 concrete blocks have been tested in this way. The tests thus far made have been carried out primarily for the purpose of studying the action of the machine. The weight of shot to be used, the proportion of small and large spheres, the rate and number of revolutions, the effect of the position of the block in the ring with reference to other blocks of the same or widely different properties, have been studied. A few variations in the mix, aggregates, condition of storage of the concrete, etc., have been made, but the tests are not considered to be of sufficient scope to justify presenting the results at this time. The loss in weight due to the test has varied from 8 to 25 per cent. Figures 3 and 4 show the appearance of representative blocks after the test. A few paving brick have been tested in the same ring as the concrete blocks, with satisfactory results.

In making the concrete test blocks it is custom to proportion and mix each block separately. Only in this way can consistent results be secured. Metal forms made from 5-in. steel channels are used. These forms make it possible to mold the blocks of uniform size and true to shape. Blocks which have been stored in water or in damp sand are allowed to dry out a few hours prior to test, in order that the weights may not be appreciably affected by evaporation during the test.

**Advantages of Rattler Test.**—This method of making wear tests of concrete is believed to have the following advantages:

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*Extract from a paper by Prof. D. A. Abrams, Lewis Institute, Chicago, before the American Society for Testing Materials.

1. The concrete is subjected to a treatment which approximates that of service.

2. The test piece is of usual form and of sufficient size that representative concrete can be obtained.

3. The test pieces are convenient to make, store and handle, and require a relatively small amount of concrete.

4. The cost of the tests is not excessive.

5. The machine used was found in numerous testing laboratories.

6. The wearing action takes place on the top or finished surface of the concrete. This makes it possible to study the effect of various surface treatments or finishes.

7. Several tests may be made at the same time, thus enabling more representative results to be obtained.

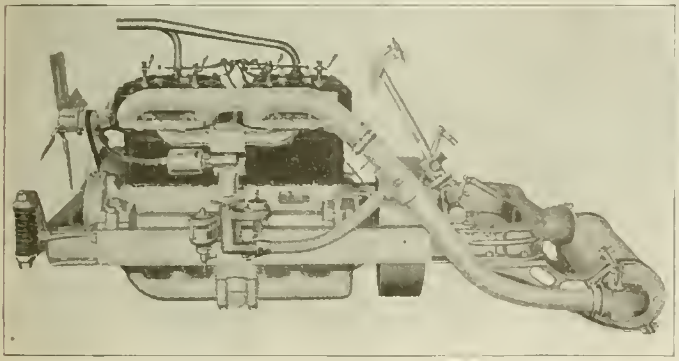
8. Tests may be made on sections of concrete cut from roads which have been in service.

9. Other paving materials, such as brick, granite blocks, etc., may be tested in the same way as concrete.

The tests indicate that this method may prove of considerable value in studying the relative merits of different aggregates, mixes, consistencies, time of mixing, surface treatment, etc., on the wearing resistance of concrete. It can readily be used as a control test on blocks made at frequent intervals as the work progresses.

## IMPROVED MOTOR TRUCK ENGINE MOUNTING.

The illustration shows a uniquely mounted motor truck engine. An independent engine frame carries at its two forward corners coiled springs which rest on brackets on the truck frame and at its rear end a ball which rests in a socket on the cross member of the truck frame. This mounting permits the main frame of the truck to cant or twist without binding or straining the crank shaft or bearings. The coiled springs are of vanadium steel and the ball has a diameter of 5 in. This construction reduces wear and friction and minimizes shocks to the engine on rough roads. As stated by the makers, crank case arms cannot be broken, crank shaft cannot bind, shaft bearings cannot become egg-shaped, crank case cannot twist or crack, power is not wasted by excessive friction. These engine mountings are used on trucks made by the United States Motor Truck Co., Cincinnati, O.



Special Mounting for Motor Truck Engines.

## ROAD BUILDING OPPORTUNITIES IN ARKANSAS.

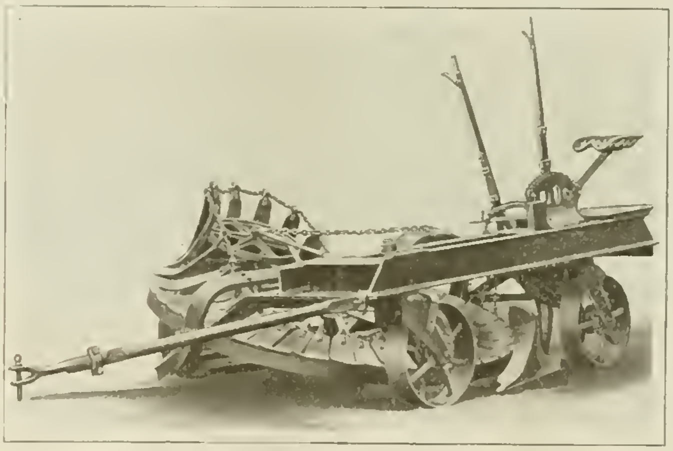
Highway construction to cost nearly $4,500,000 is a possibility of the near future in the state of Arkansas. This work will be carried out under the provisions of the Alexander Road Law, which provides for the formation of road improvement districts and the issuance of bonds. The direction of the road construction is under the supervision of the State Highway Department, of which Hugh R. Carter, Little Rock, Ark., is State Highway Engineer. The following is a list of the counties in which surveys already have been made:

| County. | Mileage. | Est. cost. |
|---|---|---|
| Pulaski | 60 | $ 60,000 |
| Sebastian | 18 | 100,000 |
| Ouachita | 50 | 200,000 |
| Carroll | 10 | 50,000 |
| Benton | 15 | 71,000 |
| Columbia | 40 | 205,000 |
| Independence | 18 | 95,000 |
| Miller | 60 | 400,000 |
| Lafayette | 60 | 125,000 |
| Pope | 40 | 180,000 |
| Newton | 25 | 150,000 |
| Boone | 20 | 110,000 |
| Washington | 32 | 156,000 |
| Arkansas | 36 | 135,000 |
| Woodruff | 40 | 210,000 |
| Perry | 20 | 100,000 |
| Randolph | 8 | 21,000 |
| Little River | 30 | 150,000 |
| Grant | 27 | 145,000 |
| Prairie | 12 | 60,000 |
| Phillips | 5 | 50,000 |
| Union | 30 | 160,000 |
| Arkansas | 25 | 150,000 |
| White | 21 | 100,000 |
| Dallas | 30 | 150,000 |
| Lonoke | 15 | 60,000 |
| Stone-Izard | 8 | 60,000 |
| Crawford | 25 | 100,000 |
| Poinsett | 20 | 200,000 |
| Craighead | 10 | 50,000 |
| Mississippi | 100 | 900,000 |
|  | 920 | $1,523,000 |

It is expected that during the next two years there will be an even greater activity in road and bridge construction in Arkansas.

## A ROTARY ROAD GRADER.

A grading machine which differs essentially from others in common use for road construction is illustrated here. A steel frame on four wheels carries a plow, a rotary conveyor and the operating levers. All parts except the rotary conveyor are familiar. The conveyor is essentially a wheel rotating at a small angle with the horizontal, and propelled, when the grader is moving, by friction on the ground and by one truck wheel over which it rides. The top of the wheel consists of a ring of steel plate "cups" hinged to the rim. In operation the plow throws a stream of dirt onto the hinged plates. As the load comes to the opposite of the wheel the plates are tilted by a dump wheel and the load is discharged. The operation is simple. The capacity of this grader is stated to be 200 to 300 cu. yd. per hour. It weighs 3,400 lb. and costs $400 f. o. b. factory. The manufacturers are Mayer Brothers Co., Mankato, Minn.



Rotary Grading Machine for Road Work.

## BUMPS AT RAILWAY CROSSINGS.

The general claim agent of the Pacific Electric Ry. Co. of Los Angeles, Cal., has petitioned the State Railroad Commission for permission to put a "thank-you-marm" 50 ft. on each side of grade crossings as a protection against speeding over railroad tracks. It is stated that the experiment of intentionally placing bumps 50 ft. on each side of railway crossings has been thoroughly worked out throughout the good roads systems of Tennessee and in the city of Memphis. It also is stated that additional experiments have been carried on in Milwaukee and in a number of states with uniformly beneficial results.

## REDUCING HAULING COSTS IN PAVEMENT CONSTRUCTION AT PITTSBURG, KAN.

A marked saving in haulage costs was effected on street paving work at Pittsburg, Kan., by the use of motor trucks. The Williams Conustruction Co. of Pittsburg, had the contract for laying a considerable mileage of National pavement. On one street the work called for the construction of one mile of this type of surfacing. The National plant was located about 2 miles from the commencement of this particular job, the average haul being about 2½ miles.

For hauling the paving material to the street the contractor used two model R 3½-ton trucks made by the Indian Truck Co. of Marion, Ind. These trucks were Sheldon worm driven and equipped with Wood's hydraulic hoists, and carried a 3½-yd. steel dump body. The rear wheels had Firestone giant tires, 36x10, which show up to very good advantage in country road building.

Indiana Trucks Used for Construction of National Pavement at Pittsburg, Kan.

The asphalt was dumped into the trucks at the plant, each batch weighing 818 lb. Ten batches were hauled at each load and 10 round trips 8 miles each were made daily, a round trip taking about 48 minutes. Part of the distance covered was on a dirt road and the rest on brick pavement.

Before the trucks were obtained the contractor employed wagons. Four trips were made daily, each team carrying five batches to the load, making the total day's work for one team and driver 20 batches hauled or 16,360 lb. of National paving material delivered on the job at a cost of $4. The cost for 10 teams and drivers delivering 163,600 lb. daily would be $40. This same amount was delivered by the two Indiana trucks at a cost of $10 per day.

An interesting feature of this work was that the construction company had been forced to recognize the laborers' and teamsters' union, but just at the time the union scale was put into effect he received his trucks and was able to lay off 10 teams.

## QUANTITY AND COMPOSITION OF STREET DUST.

Attempts have been made by Mr. Richard T. Fox of the Citizens' Street Cleaning Bureau, Inc., of Chicago, to separate the sources of dust found in the street and to determine the quantity and composition of the dust from each source. In a paper presented before the Western Society of Engineers Mr. Fox gives the following results:

The accompanying table shows the quantity of dust per 1,000 sq. yd. of surface and its composition and its distribution over the street. The street on which this particular test was made is paved with creosoted wooden block and carries a double car track, which is paved with the same material except for two rows of granite block along the outside of the outer rails. The sidewalks are of cement. The traffic is heavy, as indicated by the accumulation of dirt, 8 cu. ft. per 1,000 sq. yd. per 24 hours.

After collecting the heavy material, the dust from the sidewalk, the roadway (from the car tracks to the curb), and from the car tracks was collected with horsehair brooms and measured separately and samples of each accumulation were submitted to a chemical analysis on a dry basis.

From these data the following table was obtained:

| | Sidewalk, lb. of dust per 1,000 sq. yd. | Roadway (curbs to car tracks) lb. of dust per 1,000 sq. yd. | Street car right of way, lb. of dust per 1,000 sq. yd. |
|---|---|---|---|
| Silica | 0.96 | 4.70 | 50.50 |
| Carbon and organic matter | .67 | 3.00 | 26.00 |
| Calcium carbonate | .20 | .60 | 6.00 |
| Magnesium carbonate | .02 | .30 | 2.30 |
| Iron | .11 | .25 | 3.00 |
| Undetermined | .04 | .15 | .20 |
| Total | 2.00 | 9.00 | 88.00 |

The silica consists mainly of dirt from the street, sand and gravel from the roofs of buildings, leakage from vehicles, and the fine sand used on the car tracks to facilitate the stopping of cars.

The organic matter and carbon consists of refuse paper, manure, soot, coal and various other volatile matters commonly found in the street.

The carbonate of lime is principally from the limestone, spilled from vehicles conveying building materials, etc., and likewise most of the carbonate of lime found in the dust from the sidewalks from this source, although some of it is from the wearing down of cement sidewalks by pedestrians.

The iron content exists in the free state and the natural assumption is that most of it comes from the car tracks, although some of it is from the wheels of vehicles and from the shoes of horses and even of pedestrians.

It is interesting to compare the quantity of dust collected from a street carrying car tracks with the quantity collected from a street without car tracks. For the purpose of comparison the same classification as to the sidewalk, roadway and car tracks is maintained—a space 16 ft. wide through the middle of the street, representing the car tracks, in the case of the street without car tracks.

| | Sidewalk, lb. of dust per 1,000 sq. yd. | Roadway (curbs to car tracks), lb. of dust per 1,000 sq. yd. | Street car right of way, lb. of dust per 1,000 sq. yd. |
|---|---|---|---|
| Street with car tracks | 4.30 | 6.00 | 90.00 |
| Street without car tracks | 4.00 | 9.60 | 2.60 |

## HIGHWAY CONSTRUCTION IN KENTUCKY.

A considerable mileage of highway is now under contract or contemplated for construction this season in Kentucky. The various counties in this state are offering many construction opportunities for highway contractors. Surveys have been made for approximately 682 miles of road. The state roads fund amounts to $712,000 and the bond issues of counties or road districts for 1915 and 1916 total $6,275,000. Most of this sum will be expended this year. The following tabulation shows the work placed under construction so far this year:

| County. | Road. | Type. | Miles. |
|---|---|---|---|
| Adair | Columbia-Liberty | Water bnd. mac. | 4* |
| Ballard | Wickliffe-Barlow | Gravel surface | 2.33* |
| Bell | Greasy Creek | | 1.5† |
| Bell | Greasy Creek | | .... |
| Boyle | Danville-Houstonville | | 1.7[1] |
| Boyle | Danville-Stanford | | 3.7* |
| Boyle | Danville-Perryville | | 4.5* |
| Campbell | Waterworks | Brick | ...* |
| Clark | Winchester, Ruckerville & Vienna | Mac. resurfacing | 4* |
| Clark | Lexington | Resurfacing | 1.5* |
| Clark | Winchester-Paris | Resurfacing | 6.5† |
| Gallatin | Warsaw-Burlington | Mac. resurfacing | ...* |
| Grant | Lexington-Covington | Tarvia | .32* |
| Graves | Mayfield-Paris | | 5.85* |
| Greenup | Ohio River | Earth | .57* |
| Greenup | Riverton-Hopewell | Earth | 5* |
| Hardin | Dixie Highway | Macadam | 3* |
| Hardin | Dixie Highway | Macadam | 3* |
| Harlan | Harlan-Bell | Macadam | 9.5* |
| Harlan | Farmers Mill & Martin's Fork | Macadam | 5* |
| Harrison | Cynthiana-Carlisle | | 4.2* |
| Harrison | Cynthiana-Williamstown | | 7.42* |
| Harrison | Cynthiana-Falmouth | Mac. resurfacing | 4† |
| Hopkins | Madisonville-Hopkinsville | Mac. resurfacing | 1.5* |
| Jefferson | 18th St. Road | Rock asphalt | 17.97* |
| Knox | Big Richland Creek | Earth | 7* |
| Knox | Williamsburg | Earth | 5.9* |
| Knox | Pineville | Sandstone-Mac. | 6* |
| Laurel | London-Clay County line | Earth | 3.2* |
| Laurel | London-Manchester | Macadam | ...* |
| Laurel | London-Pittsburg | Macadam | ...* |
| Laurel | Sublimity | Macadam | ...* |
| Laurel | Corbin-Lilly | | ...* |
| Lincoln | Stanford-Boyle County line | Concrete | ...* |
| Lincoln | Crab Orchard-Rock County | Earth | 2.57* |
| Lincoln | Stanford-Crab Orchard | | ...* |
| Lincoln | Stanford-Danville | Macadam | ...* |
| Marion | Lebanon-Bradfordville | Macadam | 4.5* |
| McCracken | Noble | | 2* |
| McCracken | Clark Line | | 2* |
| Muhlenburg | | Macadam | 6* |
| Muhlenburg | Greenville | Macadam | ...* |
| Nelson | Bardstown-Springfield | Macadam | 3* |
| Nelson | Bardstown-Lebanon | Macadam | 9* |
| Nelson | Bardstown-Elizabethtown | Macadam | 6* |
| Nelson | Bardstown-Taylorsville | Macadam | 6* |
| Oldham | Buckner-Crestwood | Macadam | ...* |
| Oldham | La Grange-Shelbyville | Mac. resurfacing | 4.7* |
| Shelby | Shelbyville-Jefferson | Macadam | ...* |
| Shelby | Shelbyville-Franklin | Macadam | 5* |

*By contract. †By force account. [1]Taken over by county from contractors.

It will be noted from the above table that the contracts usually cover several miles of highway. The prevailing type of surfacing is macadam, although some contracts for brick and concrete roads have been let. R. Wiley, Frankfort, Ky., is State Commissioner of Public Roads.

## HIGHWAY CONSTRUCTION IN MINNESOTA FOR 1916.

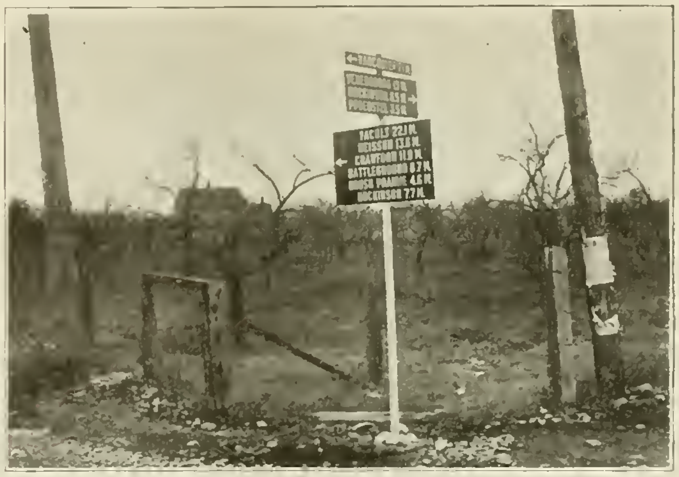
It is estimated that the various counties of Minnesota will expend approximately $4,000,000 during the present season on road work. Plans for some 860 miles of roads already have been filed with the State Highway Commission, St. Paul. An outline of the probable construction shows the following: 2,500 miles of grading on state roads, 700 miles of graveling, 150 miles of sand-clay surfacing, 35 miles of macadam, 4 miles of brick and 1 mile of concrete. The following tabulation shows the contemplated work in several counties:

| County and County Seat. | Grading. Miles. | Graveling. Miles. | Cost. |
|---|---|---|---|
| Blue Earth, Mankato | 24 | 6 | $25,000 |
| Brown, New Ulm | 12 | 10 | 23,000 |
| Carlton, Carlton | 26 | 13* | 64,000 |
| Clay, Moorhead | 53 | .. | 32,000 |
| Cottonwood, Windom | 57 | .. | 30,000 |
| Crow Wing, Brainerd | 36 | 36 | 64,000 |
| Goodhue, Red Wing | 25 | 25 | 40,000 |
| Kandiyohi, Willmar | 36 | 8 | 23,000 |
| Lacqui Parle, Madison | 28 | 9 | 39,000 |
| McLeod, Glencoe | 20 | 20 | 35,000 |
| Morrison, Little Falls | 65 | .. | 54,000 |
| Murray, Slayton | 50 | .. | 14,000 |
| Pine, Pine City | 30† | .. | 64,000 |
| Redwood, Redwood Falls | 57† | .. | 72,000 |
| Rice, Faribault | 35 | 30 | 36,000 |
| Rock, Luverne | 18 | 18 | 49,000 |
| Washington, Stillwater | 6 | 6 | 23,000 |

*28 miles of graveling to cost $32,000 will be paid for from bond issue. †Paid for from bond issue.

## ROAD SIGNS.

Clarke County, Washington, is using the sign shown in the accompanying illustration for marking its roads. The sign consists of a round standard bearing targets on which the name of the towns and their mileage are shown in white against a black background. Directions are indicated by arrows. The sign, as will be seen from the cut, is well adapted to conditions arising from different road angles. The county obtained the signs from the Coast Culvert & Flume Co., Portland, Ore., the agents in the district for the R. Harbesty Mfg. Co., Denver, Col. W. A. Schwarz, Vancouver, Wash., is the County Engineer.



Road Sign, Clarke County, Washington.

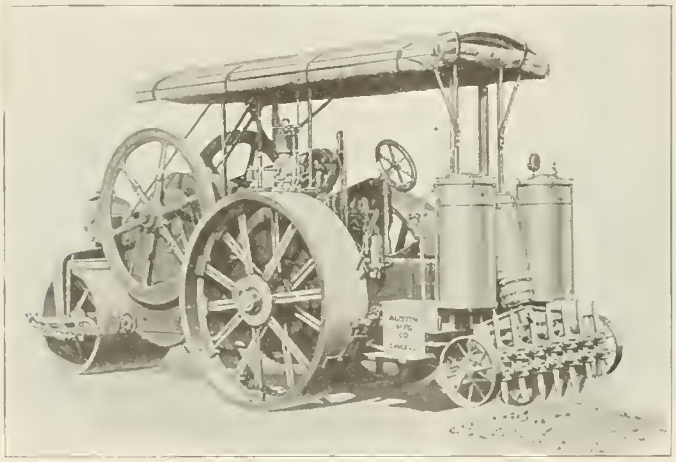
## OILING CINDER AND SLAG ROADS.

An interesting experiment in oiling a cinder and slag road between Ankeny, Ia., and Des Moines, Ia., is being carried out, according to the Service Bulletin of the Iowa Highway Commission. During the latter part of June and the first week in July the Polk County Supervisors, working in conjunction with the Highway Commission and the Good Roads Section of Iowa State College, placed ½ gal. of liquid asphalt to the square yard of road surface. The asphalt was put on with a pressure tank without any artificial heating. The temperature during this period ranged from 90 to 100°. This road was originally surfaced with slag from the coal mines. This material, while furnishing a good waterproof surface, did not have sufficient wearing qualities and wore away rapidly under the heavy automobile traffic on that road. The road officials, after scarifying the slag surface, gave the road a coating of steam cinders. This has been under traffic now for two or three months and is in fine condition for the oiling experiment. The oil being used on this experiment is a little higher class and more expensive than the average used for oiling country roads.

## PNEUMATIC SCARIFIER FOR ATTACHMENT TO A ROAD ROLLER.

A scarifier which can be attached to any standard Austin road roller is illustrated by the accompanying cut. The general design of this scarifier consists of a cylinder attached to the rear end of the roller frame, to which pressure can be applied from air storage tanks mounted on either side of the cylinder. The cylinder is connected to the scarifier by a connecting rod pinned at each end, which prevents any straining or twisting of the scarifier attachment transferring undesirable vibration or strain to the cylinder itself. The scarifier attachment consists of a hinged frame hung on the rear end of the roller frame. This hinged frame is spanned by a steel yoke attached to the lower end of the piston connecting rod, so that the downward pressure of the piston will force the scarifier teeth into the ground and keep them there during work, and by a simple reversing cock the pressure can be applied to the lower end of the piston and quickly raise the teeth out of work.

The air pressure is maintained in the tanks by a small compressor mounted on the top of the engine cylinder and operated by the engine from the crank shaft. A few minutes' running of the compressor is sufficient to raise the air pressure in the tank up to 120 lb. per square inch, which is ample for operating the scarifier, and a safety valve is supplied in the tanks which blows off at that pressure. The tanks are tested to 300 lb. pressure, so that they are absolutely safe. The tanks are fitted with a pressure gage and the compressor is fitted with an automatic cut-off, so that when the regular working pressure is reached the air compressor is automatically cut out, thus saving wear and tear and loss of horsepower.


Pneumatic Scarifier for Attachment to a Road Roller.

In the operation of this scarifier very little skill or attention is called for from the operator. One four-way cock controls all the movements; once the machine is lowered into the work, it automatically adjusts itself to the surface of the road. The air pressure in the piston accomplishes this with an ease and elasticity which is very satisfactory, this pressure at the same time acting as a buffer in protecting the roller and its parts from the strain and vibration of doing the heaviest work.

Each of the seven teeth is adjustable separately for wear and depth of cut, and is so attached that the loosened material does not clog up in front. The road wheels at each end of the scarifier simply act as guides or guards so as to adjust the depth of cut and maintain even and uniform work and to prevent the teeth from diving when soft material is met with.

This device is manufactured by the Austin-Western Road Machinery Co., Chicago, Ill.

## STREET SPRINKLING IN A SMALL CITY.

Last year Rochester, Minn., a city of about 8,000 population, began sprinkling its streets by force account. Previous to 1915 this work had been done under the contract system. Last spring, however, the charter was amended so as to allow the city to do its own sprinkling, charging to the frontage the exact cost of the work. In the July Bulletin of the Affiliated Engineering Societies of Minnesota Mr. J. C. Utton, City Engineer of Rochester, describes this work.

The city possessed four standard Austin sprinkling wagons of 600 gal. capacity. The sprinkling season covered a period of 6 months, commencing May 1 and ending Nov. 1.

The sprinkling district, which comprised some $5\frac{3}{4}$ miles of paved streets and 4 miles of unpaved streets, was divided into four districts, equalizing as much as possible the travel for each of the teams. The paved streets were sprinkled four times daily and twice on Sundays. The unpaved streets were sprinkled twice daily and once on Sundays. The average daily sprinkling travel for each team was 14.4 miles. The teams were hired by the month at $110 each. The city does not own its water works system, so the water was not free, being charged at the rate of 1 ct. per 100 gal. of metered water, each tank being equipped with a meter.

Under the charter, the cost of sprinkling each street has to be kept separate, so that special report blanks were necessary, entailing an unusually large amount of bookkeeping. Daily report blanks were furnished to the drivers, who filled them out and handed them in, containing the following information:

Date.................................Driver's Name....................
Route No..............................Tank No..........................
Meter Reading.........................Name of Street...................
Tanks of Water Used on Street...........................................
Time of Travel on Street................................................

Monthly reports were made up from the daily reports, and each street totaled up with the amount of water used and labor cost for hauling and sprinkling.

An exact record of the time taken for sprinkling each street was kept, so that if the total hours of the driver's report did not tally with the number of monthly working hours, due to wet weather, repairs, etc., then the hour cost was prorated among the different streets in proportion to the amount of time it took to sprinkle a certain street. The cost estimate for sprinkling the streets during the season was made up upon an area basis, 100 sq. ft. of surface being taken as the unit basis, street intersections being included in this estimate. The entire cost of sprinkling each street, including intersections, was assessed against the abutting property on the frontage basis. Corner property fronting on two streets that were sprinkled were assessed up in full for each frontage, the contention being that sprinkling, like paving, is a necessity and as beneficial to the property on one street as on the other. The cost to the property holders per front foot on the paved streets varied from 0.2 to 0.57 ct. and on the unpaved streets from 0.2 to 0.31 ct. The difference on the paved streets was due to a portion of the street being under construction for a short time and to an unusually wide pavement of 70 ft.

A comparison of the two systems of street sprinkling shows the following:

| | 1914. | 1915. |
|---|---|---|
| Yardage covered daily | 638,120 | 686,932 |
| Lineal feet covered daily | 135,232 | 160,656 |
| Lineal feet of actual sprinkling travel daily | 285,220* | 304,656† |

*Average of 13.5 miles per team. †Average of 14.4 miles per team.

Prior to 1915 the city had been paying out of their general fund for one-half of the water used by the contractors and furnishing to them free of charge the use of the sprinkling wagons. In 1914, under the contract system, with $3\frac{1}{2}$ miles of paved streets and 5.7 miles of unpaved streets, the city paying one-half of the water cost, the contract price was $3,086.24. In 1915, under city force account, with $5\frac{3}{4}$ miles of paved streets and 4 miles of unpaved streets, the city paying for all of the water used and charging up same to the frontage, the cost was $2,985.23.

## POST ROAD CONSTRUCTION UNDER ACT OF AUGUST, 1912.

Over 450 miles of highway have been practically completed under the direction of the U. S. Office of Public Roads under the Post Roads Act of Aug. 24, 1912. This act appropriated $500,000 for improving, under the supervision of the Secretary of Agriculture, such roads as were selected by the Postmaster General and the first named official. The local authorities in each case were required to appropriate at least two dollars to every dollar appropriated by the government. In all 17 post roads were selected for improvement. These were located in 13 states. The total mileage is 456.83 and the probable total cost of the work is $1,728,798. Table I shows the status of this work.

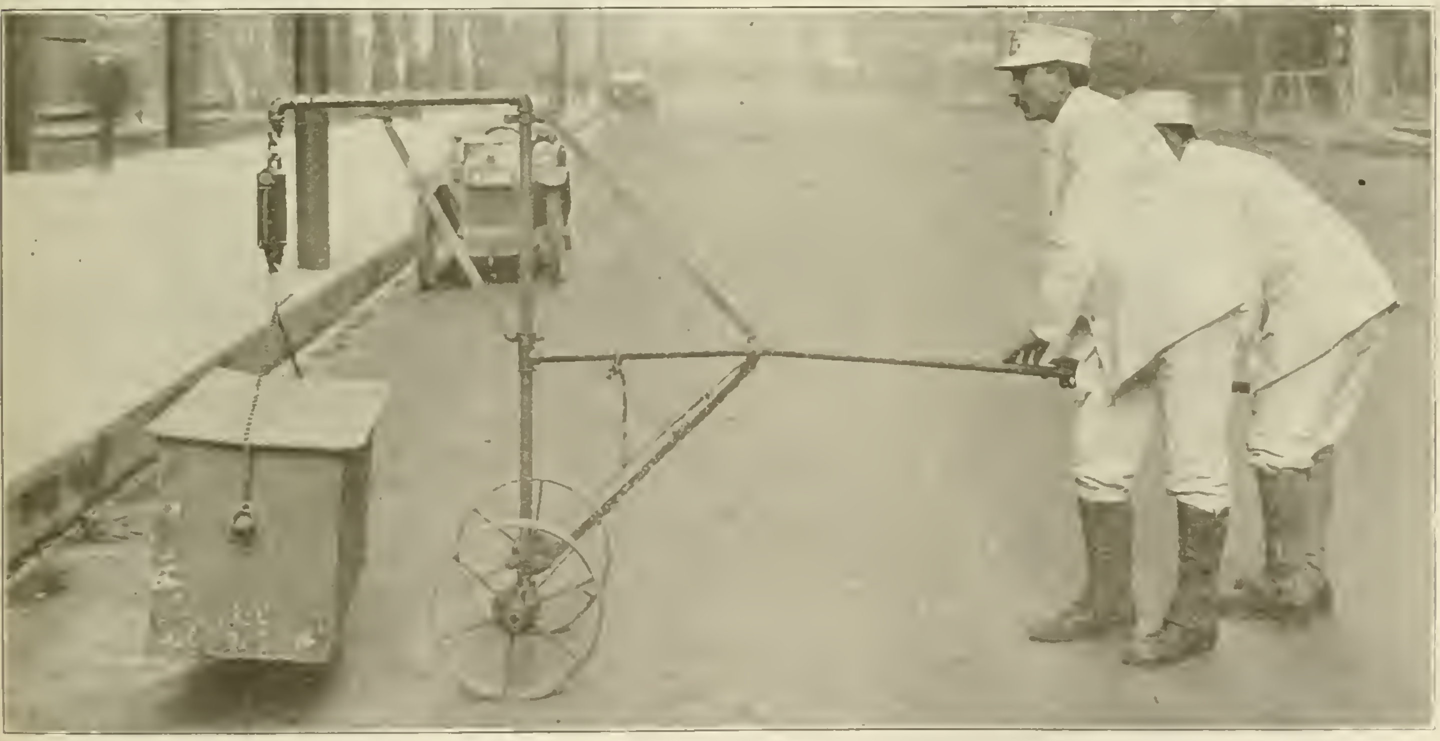
TABLE 1.—POST ROADS CONSTRUCTED UNDER ACT OF AUGUST, 1912.

| State. | Counties. | Length, Miles. | Type Construction. | Width Surfacing. Ft. | Total Cost. | Present Status. |
|---|---|---|---|---|---|---|
| Alabama | Lauderdale | 28.00 | Earth | .. | $ 29,991 | Completed |
| Iowa | Boone and Story | 51.00 | Earth | .. | 43,014 | Completed |
|  | Dubuque | 19.20 | Gravel | 15 | 115,000* | 50% Compl. |
| Kentucky | Bath and Montgomery | 10.90 | Macadam | 14 | 45,545 | Completed. |
| Maine | Cumberland | 20.94 | Bit. Mac. | 15 | 245,736 | Completed |
| Maryland | Montgomery | 5.40 | Macadam | 15 | 45,045 | Completed |
| Mississippi | Leflore | 21.80 | Gravel | 15 | 150,677 | Completed |
| North Carolina | McDowell | 16.00 | Earth | .. | 45,000* | 90% Compl. |
|  | Forsythe, Davie and Iredell | 50.82 | Top Soil | 16 | 99,754 | Completed |
| Ohio | Licking and Muskingum | 23.97 | Concrete | 16 | 440,000* | Surf. compl. |
| Oregon | Jackson | 50.50 | Earth | .. | 29,999 | Completed |
| South Carolina | Aiken | 26.98 | Sand-clay | 15 | 30,000 | Completed |
| Tennessee | Montgomery | 7.65 | Macadam | 9 | 32,422 | Completed |
|  | Loudon | 6.40 | Macadam | 14 | 32,400 | Completed |
| Texas | Bexar Guadalope, Comal, Hayes and Travis | 71.14 | Gravel | 14 & 15 | 241,856 | Completed |
| Virginia | Fairfax | 12.33 | Gravel | 14 | 54,706 | Completed |
|  | Spotsylvania, Hanover and Caroline | 33.80 | Top Soil | 16 | 47,651 | Completed |
| Totals |  | 456.83 |  |  | 1,728,798 |  |

*Estimated.

## PORTABLE WEIGHING DEVICE.

The accompanying illustration shows a portable device used by Citizens' Street Cleaning Bureau, Inc., of Chicago, for weighing street dirt and refuse. It consists, as will be seen from the cut, of pipework frame mounted on wheels. The curb boxes shown are of special design, having projections at each end to which the chain is attached.



Machine for Weighing Street Sweepings. Chicago, Ill.

## STATE HIGHWAY CONSTRUCTION IN CALIFORNIA.

The citizens of the state of California will vote in November on the acceptance of the new State Highway Act passed by the legislature of 1915. This act appropriates $15,000,000 to complete the system originally planned and to add to it certain other connecting and much needed cross-state roads.

The act of 1909 provided $18,000,000 and called for the construction of nearly 2,900 miles of roads, an average allowance of approximately $6,200 per mile, including expenses of every nature. The following statistics from the California Highway Bulletin show some of the work accomplished by the State Highway Commission under the $18,000,000 bond issue:

|  |  |
|---|---|
| Miles of road surveyed | 2,280 |
| Miles of right of way secured | 1,705 |
| Acres of right of way secured | 13,327 |
| Miles of highway constructed: |  |
| Oiled macadam | 129 |
| Concrete pavement | 933 |
| Asphalt | 33 |
| Graded | 395 |
| Total | 1,490 |
| Miles of road paved by counties and taken over, improved and maintained by the state | 108 |

Approximate quantities of work accomplished include the following:

Earth and rock moved, 11,750,000 cu. yd., at an average cost of 38 ct.

Concrete pavement laid, 8,750,000 sq. yd., at an average cost of 74½ ct.

Concrete pavement laid, 1,000,000 cu. yd., at an average cost of $6.64.

Of the $18,000,000 the Commission's balance sheet of April 15, 1916, shows the following expenditures to that date:

|  |  |
|---|---|
| Highways under construction | $14,468,082 |
| Construction plants and equipment | 181,400 |
| Surveys, expense of which has not yet been distributed to to the contract sections | 745,044 |
| Headquarters' and division offices' general expense | 725,057 |
| Total | $16,119,583 |

The unexpended balance of the fund, $1,900,000, will be used to complete the roads already under contract and for the construction of some few sections, to do which the Commission is obligated.

It is proposed to expend the funds from the new $15,000,000 bond issue for the building of about 1,400 miles of roads, this mileage including the mountain lateral. Of this sum $12,000,000 will be used for the completion of the original system of trunk roads and county seat laterals, and $3,000,000 will be applied on a county aid co-operative basis to the building of the following additional highways:

An extension connecting the interior and coast main roads through Trinity and Humboldt counties.

An extension connecting the San Joaquin Valley trunk road between Merced and Madera with the coast main road at or near Gilroy, Santa Clara County, via Pacheco Pass.

An extension of the Mariposa County state highway lateral to El Portal, Mariposa County, the gateway to Yosemite Valley.

An extension of the laterals between Visalia and Hanford, via Coalinga to connect the San Joaquin Valley main road in Tulane County with the coast trunk road in Monterey County.

An extension connecting the San Joaquin Valley trunk road at or near Bakersfield with the coast trunk road in San Luis Obispo County, via Cholame Pass.

An extension of the San Bernardino County state highway lateral to Barstow in San Bernardino County.

An extension connecting Antelope Valley, Los Angeles County, with the city of Los Angeles.

An extension of the San Bernardino County state highway lateral to the Arizona state line near Yuma, via Brawley and El Centro in Imperial County.

### STANDARD PAVEMENT SECTIONS OF PORTLAND, ORE.

A convenient method for showing the details of the various classes of pavements laid at Portland, Ore., is employed by the Department of Public Works of that city. Drawings of the standard sections are reproduced on a blue-print sheet, so that the construction and thickness of the various types can be noted at a glance. The standards cover 14 classes of pavement, for each of which there are standard specifications. The number of the specifications is given on the blue print beside the corresponding pavement section. The accompanying illustration shows the standard sections. The yardage laid and average price of these pavements last given were as follows:

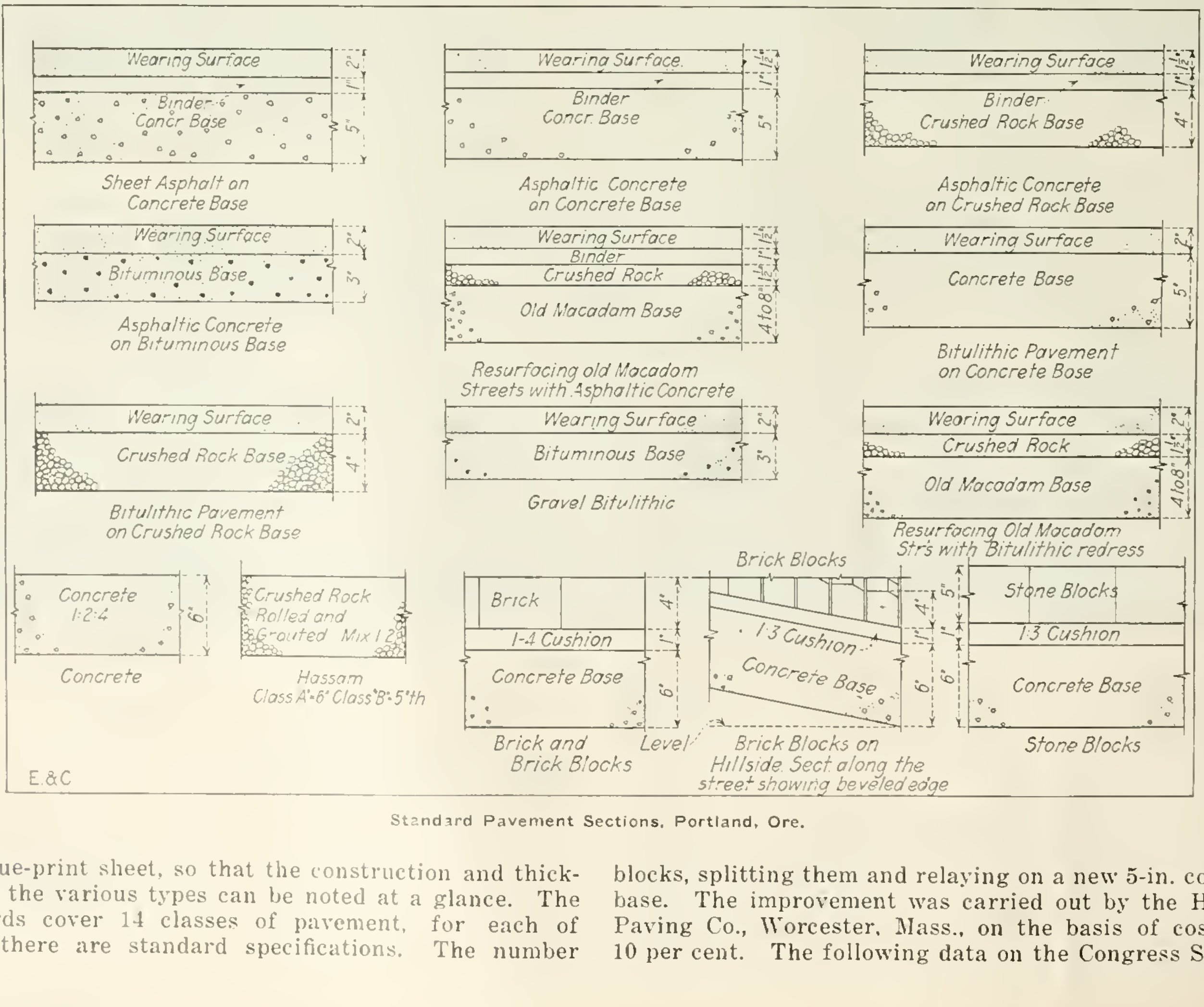
| | Sq yds. | Av. price per sq. yd. |
|---|---|---|
| Asphalt | 4,285 | $1.54 |
| Asphaltic concrete on crushed rock base | 48,101 | 1.29 |
| Asphaltic concrete on bituminous base | 87,127 | 1.12 |
| Bitulithic | 26,089 | 1.59 |
| Bitulithic redress | 15,826 | 1.18 |
| Brick | 13,741 | 2.50 |
| Concrete | 30,461 | 1.21 |
| Macadam | 20,425 | .45 |
| Gravel bitulithic | 35,566 | 1.28 |
| Hassam, Class A | 12,555 | 1.40 |
| Hassam, Class B | 5,397 | 1.27 |
| Stone Block | 4,346 | 3.15 |

These prices include the cost of the base, but do not include the cost of grading, which averaged about 35 ct. per cubic yard. The figures are based on the following material and labor prices: Portland cement, $2 per barrel; broken stone, $1.30 per cubic yard; sand, 86 ct. per cubic yard; gravel, 86 ct. per cubic yard; paving brick, $1.50 per square yard; California asphalt, $10.50 per ton; Basalt stone block, $1.60 per square yard; common labor, $2.50 per 8-hour day; paver, $5 per 8-hour day, and teams with driver, $5 per 8-hour day.

All the bitulithic pavement (laid under Warren Bros.' patents) put down during the year was on a crushed rock base. The bitulithic redress is the standard bitulithic wearing surface laid on a dry rock binder ½ in. thick on top of the old macadam trimmed up to subgrade. The comparatively low price of the asphalt pavement is explained by the fact that all of the asphalt used was manufactured in California from the natural oils. Philip H. Dater is City Engineer of Portland, Ore.

### DATA ON SPLIT GRANITE BLOCK PAVEMENT AT PORTLAND, ME.

During 1915 the city of Portland, Me., constructed 11,784 sq. yd. of pavement on Monument Square and on Congress St. The work consisted in taking up the old granite blocks, splitting them and relaying on a new 5-in. concrete base. The improvement was carried out by the Hassam Paving Co., Worcester, Mass., on the basis of cost plus 10 per cent. The following data on the Congress St. pav-


Wearing Surface
Binder
Concr. Base
Sheet Asphalt on Concrete Base
Asphaltic Concrete on Concrete Base
Crushed Rock Base
Asphaltic Concrete on Crushed Rock Base
Bituminous Base
Asphaltic Concrete on Bituminous Base
Crushed Rock
Old Macadam Base
Resurfacing old Macadom Streets with Asphaltic Concrete
Concrete Base
Bitulithic Pavement on Concrete Base
Bitulithic Pavement on Crushed Rock Base
Gravel Bitulithic
Resurfacing Old Macadam Str's with Bitulithic redress
Concrete 1:2:4
Concrete
Crushed Rock Rolled and Grouted Mix 1:2
Hassam Class A-6" Class B-5" th
Brick
1-4 Cushion
Brick and Brick Blocks
Brick Blocks
1:3 Cushion
Level
Brick Blocks on Hillside. Sect along the street showing beveled edge
Stone Blocks
E.&C.

Standard Pavement Sections, Portland, Ore.

ing are taken from the recently issued annual report of Bion Bradbury, Jr., Commissioner of Public Works.

The pavement was made up of a 5-in. Hassam concrete base, 2-in. sand cushion, split blocks, grouted with cement grout and pea stone. The unit costs were as follows:

| | Per sq. yd. |
|---|---|
| Taking up old blocks, splitting, counting, etc. | \$0.5188 |
| Excavation | .1991 |
| Foundation, 5-in. concrete base | .4896 |
| *Sand | .0849 |
| Block paving, laying, hauling and pea stone | .2201 |
| Grouting blocks | .1703 |
| Watchmen | .0310 |
| Engineering and inspection | .0194 |
| Overhead | .1539 |
| Total | \$1.8871 |
| Cost plus 10% | .1887 |
| Total cost | \$2.0758 |

*Sand furnished by city without cost, 10 per cent allowed on estimated cost of \$1 per cubic yard.

General data on the work include the following:

General size of blocks when laid, 4 in. wide, 5 in. deep, 6½ in. long.
Average number blocks split per man per day, 548.
Split blocks, per sq. yd., 34-35.
Concrete base, 1 ton eggstone covered, 7.40 sq. yd.
Concrete base, 1 bbl. cement grouted, 8.41 sq. yd.
Granite blocks, 1 ton pea stone grouted, 73.2 sq. yd.
Granite blocks, 1 bbl. cement grouted, 19 sq. yd.
Granite blocks, 1 cu. yd. sand grouted, 61.3 sq. yd.

## WEAR OF CONCRETE PAVEMENT DUE TO IMPROPER CONSTRUCTION.*

The surface of some of the pavements examined had a pebbly finish wherein the smaller pebbles were protruding more or less from the general mortar surface. This condition may be due to any one of the following causes:

Incorrect proportioning of the material wherein the mortar is too low a percentage of the total volume.

Insufficient tamping or consolidation of the mass.

Careless floating or finishing.

Taking these up in the above order:

**Proportion of Mortar to Stone.**—The first requirement of the mortar is to fill the voids in the aggregate as mixed. The first problem of proportioning is therefore to determine the probable percentage of voids in the coarse aggregate after it has assumed its final position in the concrete. In void determinations on the dry aggregates, each particle of aggregate is in contact with every other particle adjacent thereto at one or more points, but when mixed in a concrete each particle of aggregate will be coated with a film of mortar and separated from each of its neighbors, a distance at least equal to the thickness of this film. On the other hand the lubricating action of the mortar makes possible a greater degree of consolidation than is usually secured with the aggregate dry. These two factors tend to neutralize each other. However, under ordinary field conditions, particularly those prevailing in pavement construction, the space to be filled with mortar will be somewhat greater than the voids measured in the dry coarse aggregate. It is also apparent that the amount of such "spreading" of the stone particles will vary with the voids in the original aggregate, with the ratio of mortar to stone, with the ratio of sand to cement, and with many other factors, such as the consistency, etc. For the best consolidated cores examined, data as to the increase in per cent of voids after mixing was obtained. This is such as to indicate a spreading action varying with the percentage of voids in the original material as shown in Fig. 1.

If the data given in Fig. 1 be taken as a basis for the amount of spreading of the stone particles which may be expected with the best consolidation ordinarily obtained, and for proportions as hereinafter recommended, the following calculations show the proportion of mortar to stone which will give the best results:

Let

$G$ = The percentage of voids in the original material.

$P$ = The percentage (of the whole) increase in voids due to the spreading action of the mortar.

$V$ = Absolute volume of stone in a unit volume of stone $= 1 - G$.

Then

$V_a$ = The absolute volume of stone in a unit volume of the concrete as mixed will be $1 - (G + P)$.

The loose volume of mortar required to fill the voids in the stone is obviously (for a unit volume of concrete) $(G + P)$ and the ratio of mortar to absolute volume of stone will be:

Mortar: Absolute volume of stone:

$$(G + P) : [1 - (G + P)]$$

It now remains to decide upon the economical thickness mortar covering for the pavement and to proportion the mortar to stone so that there will be excess mortar sufficient to properly finish the surface. The condition of the surfaces examined was such as to indicate that when the mortar covering was less than ¼ in. in thickness, certain mechanical and chemical conditions greatly increased the tendency for such a surface coat to scale. One-quarter inch, therefore, probably represents the minimum thickness of mortar covering for which the proportions should be designed. This is about three per cent of the ordinary pavement thickness. The mortar necessary to fill the voids and furnish in addition, a carpet coat whose thickness is given by the following ratio:

Mortar: Absolute volume of stone:

$$[.97(G + P) + .03] : [.97(1 - (G + P)]$$

In other words, the absolute volume of stone which can be accommodated by a unit volume of mortar is

$$\frac{.97[1 - (G + P)]}{.97[(G + P) + .03]}$$

It is now only necessary to determine the absolute volume of sand and cement in the above quantity of mortar and the proportions can be readily determined by substitution of the constants from the curve of Fig. 1.

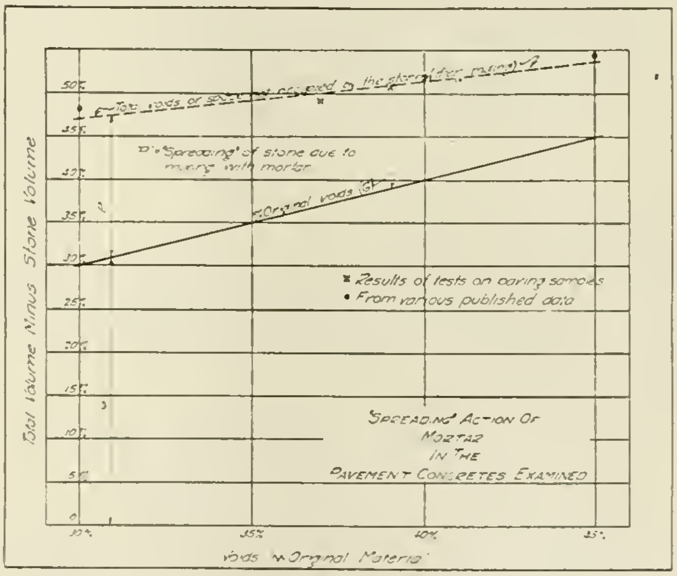


Fig. 1.—Curves Showing Spreading Action of Mortar in Concrete for Pavements.

**Insufficient Consolidation.**—Inefficient tamping may result in a stony or pebbly surface. In order to consolidate the stone and to flush the mortar to the surface, thorough tamping is absolutely necessary and the consistency should be such that this consolidation is possible. It is apparent that even though there is an excess of mortar in the mix, it is quite possible, through insufficient consolidation, to have the excess mortar deposited at the bottom of the layer instead of at the top.

Careless floating or surface working. Even with correct proportions and thorough tamping, some small portions of the aggregate will probably be present very near the surface and must be worked into the mass by careful floating of the surface. Care should be exercised to avoid excessive floating which may cause scaling.

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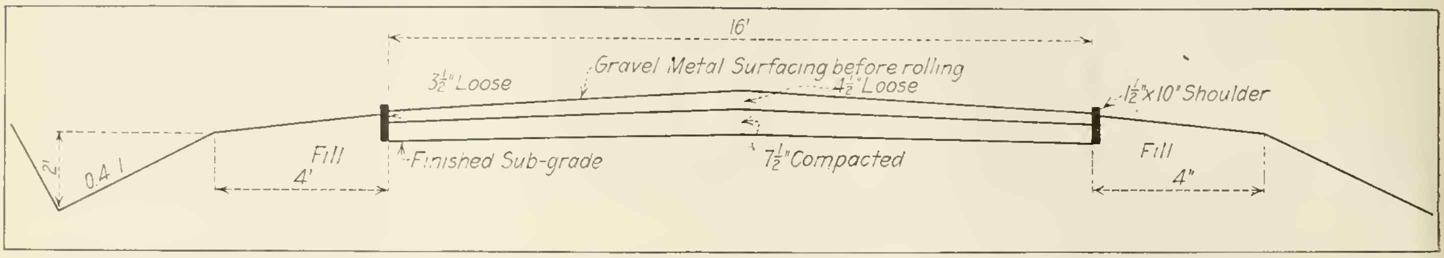
*Discussion based on exact studies of Iowa concrete pavements and published in Technical Report No. 1, Iowa State Highway Commission, by T. R. Agg and C. B. McCullough.

## PRIMING GASOLINE ENGINES WITH ETHER.

In cold weather frequently it is difficult to start the gasoline engine of a motor truck, road roller, etc. Even in warm weather there are occasional difficulties of this sort, particularly where the engine is large. It has been found advantageous to use ether for priming, instead of gasoline, for a heavy motor may thus be started with very little effort. A very small quantity of ether inserted in the cylinders will enable the operator to start the motor on the first quarter-turn.

## COMBINATION GRAVEL AND CLAM SHELL ROAD.

A combination gravel and clam shell surfacing is being used in some of the state highway work in Louisiana. This road consists essentially of a thin gravel wearing surface composed of a mixture of sand-clay gravel and washed gravel on a clam shell base. A typical section of this type of construction is shown in the accompanying illustration. The sand-clay gravel is the bank gravel or pit run gravel. This is mixed with the washed or screened gravel to increase the percentage of rock in the metal surfacing.



Sand-Clay Washed Gravel Metal Surfacing on Compacted Clam Shell Base.

The approximate quantities of material required for a road of the width and thickness shown in the cut are as follows:

| | Per mile cu. yd. loose measurement. |
|---|---|
| Sand-clay gravel | 609 |
| Washed gravel | 435 |
| Clam shells | 2,407 |

It is estimated the 2,407 cu. yd. of clam shells compact to 1,564 cu. yd. under rolling. The gravel mixture is spread to a depth of 3½ in. loose measurement at the sides and 4½ in. loose measurement at the crown and compacted by rolling.

## SAND-CEMENT BED AND MORTAR BED IN ILLINOIS BRICK ROAD CONSTRUCTION.

The State Highway Department of Illinois has abandoned the use of the sand cushion in the construction of brick paved roads. The specifications of the department, edition of March, 1916, provide for two types of brick road construction—one with the sand-cement bed, the other with the mortar bed. The specifications for the concrete base and the pavement bed for these two types include the following provisions:

### With Sand and Cement Bed.

**Concrete Base.**—The concrete for the pavement base shall consist by volume of 1 part cement, 3½ parts of fine aggregate and 6 parts of coarse aggregate where the fine and the coarse aggregates are used separately. One sack of cement will be considered as 0.95 cu. ft.

The concrete for the base shall be placed between the forms, the entire thickness of the concrete being placed at one time. The concrete shall be placed also in successive batches for the entire width of the pavement and in a continuous operation.

The base shall be struck true to shape by means of a template which shall be drawn along supported by the forms. After the base has been placed, it shall be kept wet for four days and no hauling upon it or rolling or tamping of brick will be permitted for two weeks. Should there appear any uneven places in the surface of the base to exceed ¼ in. from the proper shape as shown on the plans, then all such uneven places shall be repaired, so that the upper surface of the base shall be smooth, true, uniform and parallel with the surface of the finished pavement.

**Sand Cement Bed.**—The bed shall consist of one part of cement to four parts of fine aggregate, thoroughly mixed dry until there exists a uniform color throughout. It shall be spread dry upon the concrete pavement base to a thickness of approximately ¾ in. and rolled with a hand roller weighing not less than 15 lbs. per inch or width or otherwise compacted. After the bed has been carefully rolled, it shall be struck off to the desired cross-section by means of a templet drawn along the top of the forms. The templet shall be so adjusted as to give a thickness to the bed of ¾ in. The operations of shaping the concrete foundation for the pavement and of shaping the bed for the brick are considered as of prime importance in securing the desired evenness in the finished pavement, and the contractor will be required to equip himself with proper implements and to secure skilled men for this part of the work.

All bed placed upon the concrete base shall be covered with brick the same day, and all bed placed in excess of what can be covered with brick the same day shall be removed from the base, prior to the close of the day's work.

The contractor shall take due precaution by the use of tarpaulins or otherwise to protect the bed against dampness until the brick have been laid and rolled.

Bed that becomes moistened, prior to the rolling of the brick shall be removed and replaced with dry bed by the contractor at his expense.

### With Mortar Bed.

**Concrete Base.**—The concrete for the pavement base shall consist by volume of 1 part cement, 3½ parts of fine aggregate and 6 parts of coarse aggregate where the fine and the coarse aggregates are used separately. Where unscreened gravel is used, the concrete shall comply with the requirements of article 49. One sack of cement will be considered as 0.95 cu. ft.

The concrete for the base shall be placed between the forms, the entire thickness of the concrete being placed at one time. The concrete shall be placed also in successive batches for the entire width of the pavement and in a continuous operation. In placing the concrete base, the workmen shall be guided by a light wood template resting on the side forms, so made as to leave the concrete a little in excess of the depth required. The upper surface of the base shall be smooth, true, uniform and parallel with the surface of the finished pavement.

**Mortar Bed.**—Over the concrete base shall be drawn a multiple steel template consisting of a 6-in. I-beam in the front and a 6-in. channel in the rear, both being placed in a metal frame and fixed 2 ft. apart center to center. At each end the metal template shall be mounted on two rollers, at least 3 ft. apart, which ride on the side forms. The I-beam shall be 3/16 in. lower than the channel, and shall strike off the concrete base practically to a true surface. The center space between the I-beam and the channel shall be kept filled with dry mortar.

The concrete base shall be covered with a 3/16 in.

coating of this dry mortar, consisting of one part of Portland cement to three parts of sand. The channel which constitutes the rear template, distributes the thin film of dry mortar over the surface of the concrete base, leaving the surface entirely smooth.

This type of multiple template, constructed of the I-beam, channels, rollers, etc., is an essential of this type of brick pavement construction and no substitute will be accepted therefor unless approved in advance by the engineer.

## COST OF ASPHALTIC OIL TREATMENTS AT PORTLAND, ME.

The Department of Public Works of Portland, Me., maintains a considerable mileage of the macadam surfaces of the city by asphaltic oil treatments. The cost of the work in 1915, according to the recently issued report of Bion Bradbury, Jr., Commissioner of Public Works, is given in Table I.

TABLE I.—COST DATA ON OIL TREATMENT OF MACADAM IN 1915.

| Street. | Gallons bitumen. | Material, cleaning, application | Sanding. | Total cost. | Area, yd. | Cost per yd | Gal. per yd. | Loads of sand. | Road metal. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| Beacon, Lincoln to Prospect | 115.5 | $ 28.10 | $13.50 | $ 41.60 | 1,871 | $0.0222 | .23 | 5 | Wat. macadam | Texas Co. Liq. Asphalt, 65%. |
| Bowdoin, Neal to W. Prom. | 866.4 | ..... | ..... | 70.77 | 2,890.6 | .0244 | .29 | .. | Wat. macadam | 366.4 gal. Socony Liq. Asphalt, No. 1.<br>500 gal. Texas Co. Liq. Asphalt, 80%. |
| Carleton, Congress to Pine. | 825 | ..... | ..... | 100.83 | 2,124.75 | .0474 | .38 | .. | Bit. macadam.. | Texas Co. Liq. Asphalt, 80%. |
| Chestnut, Congress to Cumberland Ave. | 551.4 | ..... | ..... | 52.07 | 1,066 | .0488 | *.51 | .. | Wat. macadam | 276.4 gal. Socony Liq. Asphalt, No. 1.<br>275 gal. Texas Co. Liq. Asphalt, 80%. |
| Congress, Lowell to Park Ave. | 634.7 | ..... | ..... | 55.00 | 2,689.3 | .0204 | .23 | .. | Bit. macadam.. | Socony Liq. Asphalt, No. 1. |
| Congress, Stroudwater crossing, e'ly | 2,767.5 | ..... | ..... | 195.90 | 5,364 | .0365 | .51 | .. | Wat. macadam | 850.5 gal. Texas Co. Liq. Asphalt, 65%.<br>1917 gal. Socony Road Oil, No. 6. |
| Congress, Stroudwater crossing, w'ly | 1,498.1 | ..... | ..... | 94.71 | 3.065 | .0309 | .49 | .. | Wat. macadam | Texas Co. Liq. Asphalt, 65%. |
| Cumberland Ave., High to Preble | 1,277.6 | 83.01 | 30.50 | 113.51 | 5,573.7 | .0203 | .23 | 26 | Bit. concrete... | 777.6 gal. Texas Co. Liq. Asphalt, 65%.<br>500 gal. Texas Co. Liq. Asphalt, 80%. |
| Danforth, High to State... | 1,700 | ..... | ..... | 128.74 | 2,857 | .0450 | .59 | .. | Wat. macadam | Texas Co. Liq. Asphalt, 80%. |
| Danforth, St. John to Vaughan | 777.6 | 51.03 | 16.50 | 67.53 | 3,361 | .0201 | .23 | 9 | Bit. macadam.. | Texas Co. Liq. Asphalt, 65%. |
| Deering's Oaks | 3,800.8 | ..... | ..... | 244.25 | 12,434 | .0196 | .30 | .. | Gravel ........ | Socony Liq. Asphalt, No. 1. |
| Eastern Prom., Congress to Morning | 1,175.1 | ..... | ..... | 124.85 | 6.673 | .0187 | .18 | .. | Bit. macadam.. | Socony Liq. Asphalt, No. 1. |
| Franklin, Cumberland Ave. to Federal | 348.3 | 18.61 | 10.25 | 28.86 | 1,432 | .0201 | .24 | 5 | Bit. macadam.. | Texas Co. Liq. Asphalt, 65%. |
| Pine, Vaughan to W. Promenade | 800 | ..... | ..... | 63.46 | 2,230.4 | .0284 | .36 | .. | Gravel ........ | Texas Co. Liq. Asphalt, 80%. |
| Sheridan, Cumberland Ave. to Monument | 372.6 | 24.85 | 10.50 | 35.35 | 1,100 | .0321 | .34 | 4 | Wat. macadam | Texas Co. Liq. Asphalt, 65%. |
| State, Spring to Congress.. | 2,615 | ..... | ..... | 204.05 | 1,507.5 | .1353 | *1.73 | .. | Wat. macadam | 1,215 gal. Texas Co. Liq. Asphalt, 80%.<br>1,400 gal. Socony Road Oil, No. 6. |
| Stevens Ave., Congress to Brighton | 3,100 | ..... | ..... | 215.09 | 8,186 | .0262 | .38 | .. | Wat. macadam | Socony Roal Oil, No. 6. |
| Vaughan, Bramhall to Carroll | 1,600 | ..... | ..... | 153.06 | 6,163 | .0248 | .26 | .. | Bit. concrete... | Texas Co. Liq. Asphalt, 80%. |
| Vaughan, Carroll to Danforth | 1,166.4 | 69.05 | 45.75 | 114.80 | 6,081.2 | .0188 | .19 | 19 | Bit. macadam.. | Texas Co. Liq. Asphalt, 65%. |
| West, Vaughan to W. Promenade | 800 | ..... | ..... | 66.71 | 2,451 | .0272 | .33 | .. | Gravel ........ | Texas Co. Liq. Asphalt, 80%. |
| Western Promenade | 1,320.6 | ..... | ..... | 141.72 | 9,958 | .0142 | .19 | .. | Wat. macadam | Socony Liq. Asphalt, No. 1. |
| Woodford, Highland Sq. to M. C. R. R. | 1,976.4 | 116.41 | 42.50 | 158.91 | 6,396 | .0248 | .30 | 20 | Wat. macadam | Texas Co. Liq. Asphalt, 65%. |
| Totals | 31,019.0 | ..... | ..... | $2,171.77 | 95,477.45 | ..... | ... | .. | ................ | ........................................ |

*Two coats.

## HYDRATED LIME IN CONCRETE PAVEMENT CONSTRUCTION.

Hydrated lime was used in mixing the concrete for an alley pavement laid last year at Pittsburg, Kan. The paving covered one block of alley, 16 ft. wide, and amounted to 538 sq. yd. The pavement was of the single course type and had a uniform thickness of 6 in.

The proportions were 1 part Portland cement, 1 10 part (by volume) of hydrated lime, 2 parts river sand and 4 parts Joplin chats (mine tailings), two-thirds of which would pass a ¼-in. screen. The pavement cost 99 ct. per square yard, not including the grading. This cost is based on the following prices: Cement, $1.20 per bbl.; Joplin chats, $1 per cu. yd.; sand, $1.50 per cu. yd., and common labor, $2 per 8-hour day.

The objects hoped to be gained by the addition of the lime were the following: To make the mixture more plastic and more easily worked into place; to make the resulting concrete denser. The Joplin chats are flint and on account of their hardness and smooth surface the resulting concrete mixture does not cling together as it should. The hydrated lime counteracts this tendency to some extent.

No detrimental effects from the use of the lime have been observed. The traffic in the alley is extremely small—probably not averaging 3 teams per day—and this consequently sheds no light on the durability of the concrete. L. Z. Curfman is City Engineer of Pittsburg, Kan.

## CONVICT LABOR IN ROAD WORK IN CALIFORNIA.

Convict labor, according to the California Highway Bulletin, has been used with marked success in the construction of mountain roads in California. The law under which this work has been undertaken became effective last August. In September the first camp of 30 men was established in northern Mendocino County. The scope of the work was gradually enlarged, and two camps with 125 men were carried through the winter, working every day but Sunday through a rain and snow fall of 70 in.

The State Highway Commission has had charge of the laying out and direction of the work, and also the providing of camps, commissary, etc. The discipline of the men has been in the hands of the Board of Prison Directors, represented by three unarmed men in each camp—one acting as captain of the camp, the others as subforemen of the work.

Through the winter 8 miles of difficult canyon road was built at a cost 25 per cent less than the estimate, and a little more than half what similar work has cost on contract in the same locality. The success of the work in Mendocino led to the placing of a crew from the Folsom prison on a section of the Placerville road, near Shingle Springs. It is stated that this expedient will give the equivalent of $18,000 in work for an expenditure of $5,000. The Commission will make a further extension of the scheme by placing convict camps on four of the Sierra lateral roads for construction this summer.

## METHODS AND COST OF OILING EARTH ROADS IN ILLINOIS.

The oiling of earth roads has been practiced on a small scale in a number of states for the past 15 years. California has done more of this work than any other state, primarily on account of its natural resources and climatic conditions. It has successfully maintained many of its roads by this method, largely on account of the high-grade oil that is available at a very low cost, and also on account of the sandy condition of the soil and the prevailing light winters. In Illinois the practice of oiling of earth roads is comparatively new, yet enough of this work has been done to show that it is a justifiable expense on a great many earth roads. As a result a large amount of this work is now being done, and a considerable mileage of oiled earth road also is being constructed. It is probable that Illinois is now doing more work of this kind than any other state. The following description of the oiling methods in Illinois is taken from a bulletin prepared by B. H. Pepmeier, Maintenance Engineer, Illinois State Highway Department, from a paper by Mr. Piepmeir presented before the State Farmers' Institute, and from the Standard State Specifications:

**Selection of Roads for Oiling.**—Roads should not be oiled until they have a permanently established grade. Low, flat, undrained roads should not be oiled until proper drainage has been attended to. Roads that have a preponderance of heavy hauling should not be selected for oiling. The oiling tends to waterproof the road, but it is readily understood that continued heavy hauling even on perfectly dry earth roads eventually will rut and dig them out in pot holes. The mixture of oil and earth lacks stability to meet all the requirements. On moderately traveled roads where there is a greater amount of pleasure travel the oiled earth roads will give better service.

**Perfection of Earth Road.**—The mistake is often made of attempting to improve a road without first grading and draining it. When a road is graded for oiling, graveling, or any other form of surfacing, a permanent grade line should be established. The great advantage of establishing a permanent grade and cross-section before the road is oiled is to utilize the oil-soaked crust of earth as a foundation for later improvements, such as gravel, stone, brick or other hard road surfaces. If oil, gravel, or other surfacing material is applied to an improperly graded road, a very large portion of the material will be disturbed and practically wasted when later improvements are demanded.

**The Road Surface Preparatory to Oiling.**—As the prime objects of oiling an earth road are the suppression of the dust and the maintaining of a smooth waterproof surface, it is very important that the road surface be oiled when it is smooth, free from dust, and in a condition to absorb the oil.

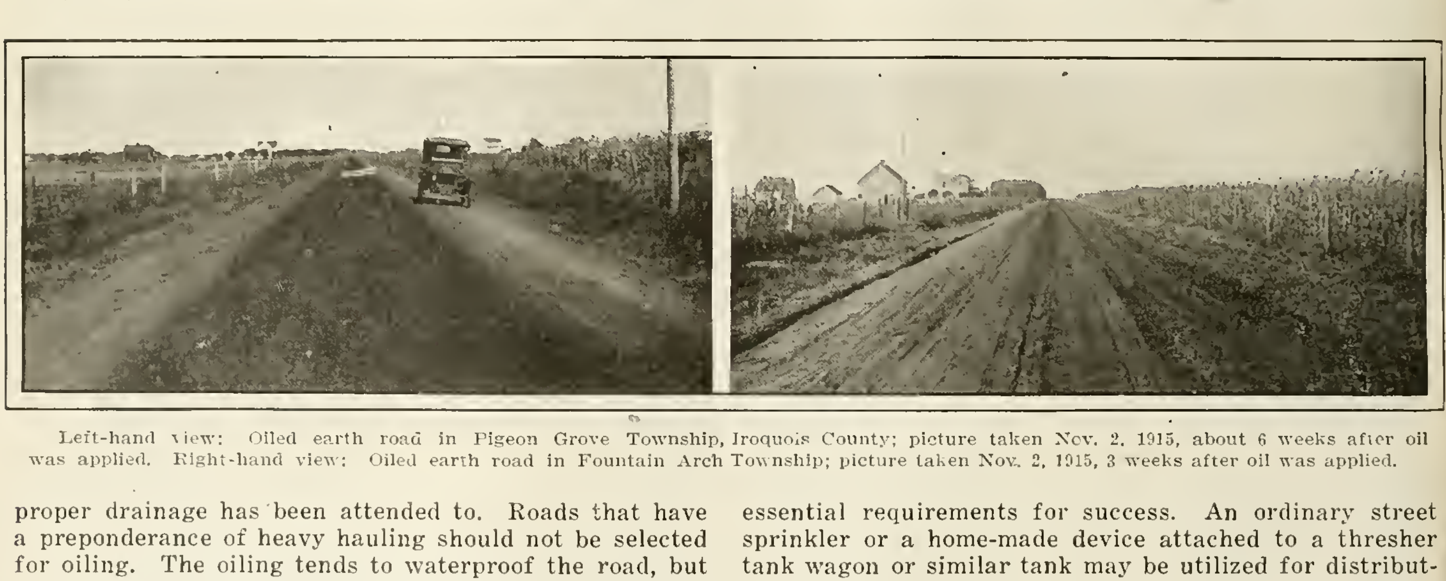
Oil applied on dust will not penetrate the road surface, but will merely mix with the loose material to make an oiled-dust surface that is apt to fly readily and become a nuisance. The surface should be perfectly smooth and free from low places that will retain water. If water is allowed to stand upon an oiled earth surface, a bad mud hole will soon result. A moist subsoil preparatory to oiling is not serious, though best results may be expected when the road is reasonably dry for about 2 in. on the surface.

**Applying Oil.**—After the road has been prepared, the oil should be applied at the rate of ¼ to ½ gal. per square yard of surface. If the road has never been oiled, or if more than a season has elapsed since a previous oiling, it will be found that about ½ gal. per square yard will be required. If the road or street has been oiled regularly ¼ to ⅓ gal. per square yard will usually be satisfactory. It is much better to apply a small amount of oil twice each season rather than to put on the full quantity in one application. When too much oil is applied, it is not only wasted, but is often very disagreeable to traffic.

After a road has been oiled for several years, one light application each year may be sufficient, or at least equal in results to two applications per year on a new oiled road.

The time for oiling will necessarily vary considerable, depending upon the season. Favorable times for applying the oil will be about April and September.

The uniform distribution of the material is one of the essential requirements for success. An ordinary street sprinkler or a home-made device attached to a thresher tank wagon or similar tank may be utilized for distributing the oil. An expert using such equipment can ordinarily get the required amount of oil on the road rather uniformly. Much better results, however, can be secured by the use of some specially designed apparatus made for the purpose, such as pressure distributor tank wagons.



Left-hand view: Oiled earth road in Pigeon Grove Township, Iroquois County; picture taken Nov. 2, 1915, about 6 weeks after oil was applied. Right-hand view: Oiled earth road in Fountain Arch Township; picture taken Nov. 2, 1915, 3 weeks after oil was applied.

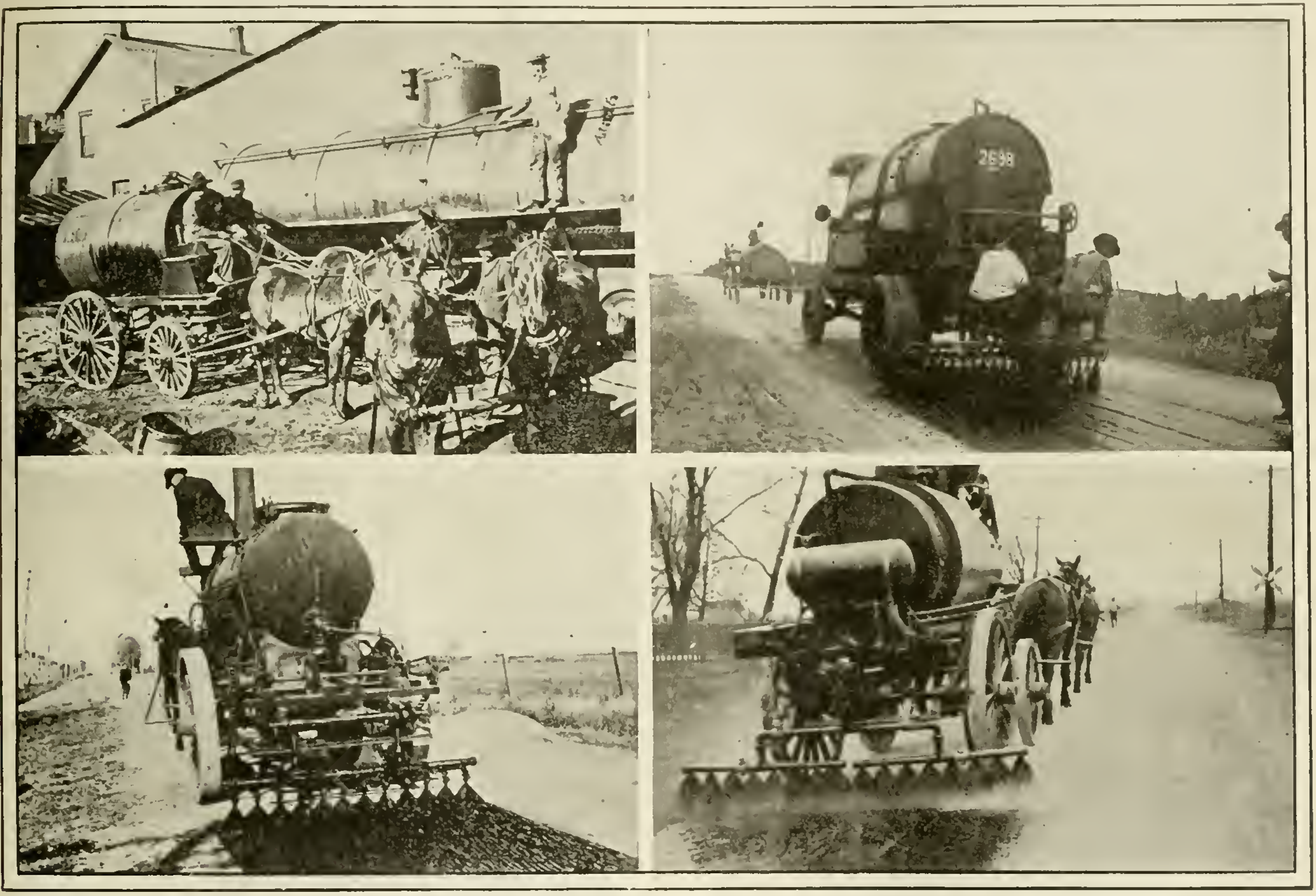
There are a number of specially designed pressure distributing wagons on the market that vary in price from $400 to $6,000. The horse-drawn distributors have a capacity of from 450 to 600 gal. and can be purchased at from $400 to $600. Such distributors are usually equipped with some form of heating device so that hot oil may be applied when required.

Some of the auto distributors hold 1,000 gal. and are equipped with oil heaters for heating the oil quickly; also, special oil pumps for filling the distributor and for spraying the oil upon the road in the desired quantities. Such trucks cost from $5,000 to $6,000 complete.

**Shipping and Handling Oil.**—Road oil is usually shipped in 8,000 or 10,000-gal. tank cars. Some companies are able to furnish 4,000 and 6,000-gal. tank cars, but such cars are very few and usually hard to get. The railroad tank cars are equipped with steam heating coils so the material may be heated in the tank by attaching a steam pipe or hose. Small quantities of oil may be purchased in molasses barrels, but when delivered in barrels there will be an additional cost of 2 to 3 ct. per gallon. The tight barrels will ordinarily hold about 50 gal. If the barrels are handled with care they can be sold at 50 to 65 ct. each when empty. Heavy oil shipped in this manner is usually very difficult to remove from the barrels. In such cases the barrels are dumped into an open heating kettle and broken. After the oil is warm the staves and hoops may be removed by a large hoe or rake and used as kindling. The hot oil can be pumped from the heating kettles to the distributor and, while still hot, applied on the road.

Where there is no heating kettle on the job and there are but a few barrels of heavy oil to apply, they may be emptied direct into the distributing wagon by first placing the barrels in a very warm room or close to a fire for several hours.

When there is but a small quantity of oil desired, say 3,000 or 4,000 gal., it is usually cheaper and much more economically handled if shipped in large tank car. Freight will have to be paid on a full tank car of 8,000 or 10,000 gal., but this will ordinarily be compensated for by the saving in barrels and in the economy effected in handling the oil on the job.



Upper left-hand view: Unloading hot oil from railroad tank car into distributor by means of rotary pump attached to tap in bottom of car; tank car heated with steam from adjacent ice plant. Upper right-hand view: 800-gal. auto pressure oil distributor for applying cold oil. Lower left-hand view: Pressure distributor for applying hot or cold oil, owned by State Highway Department; heat supplied by coal furnace under tank. Lower right-hand view: Applying heavy asphaltic material at rate of ¼ gal. per sq. yd. of surface; material is heated by kerosene burners beneath the tank.

**Pumping Oil.**—There are a number of special oil pumps on the market that can be purchased at from $15 to $30 that will readily pump hot or cold oil. The rotary pump is the one most commonly used. It may be driven by a gasoline engine or a steam engine, in case the latter is needed at the tank car for supplying steam heat. A 1½-in. or 2-in. rotary pump will fill a 600-gal. distributor in from 10 to 15 minutes.

The ordinary water tank pump may be used for pumping cold oil. A 2-in. suction tank pump will fill a 600-gal. tank in 30 to 40 minutes. Such pumps cannot be used for hot oil, as it will soon burn out the valves.

All of the above named pumps work best attached to the bottom of the railroad tank car by means of a hose or pipe. However, it is well to eliminate hose connections as much as possible, as some oils and tars eat them out very rapidly.

A 3-in. or 4-in. lift pump may be used to an advantage in pumping oils. Such pumps are set in the tank car at the top and one man will readily pump a 600-gal. tank in 20 minutes. This kind of pump can be purchased for $20 to $25. It has many advantages as there is no mechanical power needed nor any pipe or hose connections.

After the pump is connected at the bottom of the tank car and everything is ready to receive the oil, the cap on the dome of the car should be unscrewed and the discharge valve opened from the inside. This valve has a stem projecting up to the dome. It is well to have a cut-off valve in the hose or pipe connection at the bottom so the tank car valve may be left open during the day that oil is being used.

If there is an elevated siding or switch 8 or 10 ft. high at the station, the tank can be spotted thereon and the oil allowed to flow by gravity into the distributing wagon from the tap in the bottom of the tank car.

**Heating Oil**—Where oil must be heated before being applied, it is often convenient to spot the car on a spur near some steam plant, such as a mill, creamery, or electric light plant. Where such arrangements can be made, a ¾-in. or 1-in. steam pipe line may be connected from the plant to the tank car. If no steam plant is accessible, an ordinary steam tractor or roller can be connected with the tank car. Where a steam connection is made for supplying the heat, from 12 to 24 hours are required to bring the oil up to 150° to 175° F., which is about the maximum temperature that can be reached with the steam heat. This temperature will permit the oil to be pumped readily. Its temperature may then be increased the desired amount in the distributor.

The steam connection with the tank car is made at one of the 2-in. pipes that project beneath the tank, the other 2-in. pipe that projects should be supplied with a valve so the amount of steam passing through the coils may be regulated.

It is advisable to have a thermometer on the job so that the temperature of the hot oil may be tested from time to time.

Some road oils have a very low flash point and extreme care should be taken to prevent any oil from coming into contact with a flame. An analysis of an oil always shows the flash point, so it is well to keep the temperature somewhat lower to prevent burning and to be on the safe side.

The presence of a slight amount of water in heating oil will cause the oil to foam and give a great deal of trouble. Where the oil tends to foam, it should be heated very slowly. In such cases every precaution should be taken to prevent accidents.

**Sanding Oil Surfaces.**—Better results can be secured from sanding the road slightly after either hot or cold oil has been applied. Clean, hard sand is much better on a road surface than dust or the sweeping from the road. A hot oil application should be followed with a light dressing of sand, or the traffic will likely pick up the oil and make the surface of the road very uneven. Sand may be applied at the rate of 1 cu. yd. to each 100 to 150 sq. yd. of road surface. It may be applied by shovels from a wagon or from a special apparatus for distributing the sand.

The application of sand gives an oiled earth surface more stability. The sand retains the oil, assists in preventing wear, and aids in keeping down the dust. The light application of sand is a justifiable expense on a majority of oiled earth roads.

**Oiling Sandy Roads.**—There are many sections of roads in Illinois that are very sandy and will have to be handled differently than the ordinary earth road. Where it is possible to mix clay or loam with the top 4 or 5 in. of sand before oiling, much better results may be expected. A suitable clay or loam can usually be secured at a reasonable distance from the sandy section. Where possible, the sand and clay should be thoroughly mixed and allowed to compact under traffic before the oil is applied. The sand-clay road will permit a slightly heavier oil than the ordinary earth road.

If there is no clay or loam within reasonable distance of the sand road, it may be materially improved by mixing a heavy oil (70 to 90 per cent asphaltic product) with 4 or 5 in. of the top layer of sand. This can best be done by applying about ¾ gal. of oil and then covering it with about 1 in. of the sandy soil from the road side, then applying about ½ gal. of oil and another layer of sand. By building up successive layers of oil and sand, it is possible to get from 1½ to 2 gal. of oil per square yard of surface. This amount of oil mixed with 4 or 5 in. of the sandy soil will form a solid oil and sand crust that will hold up light traffic. The cost of such applications will vary from $800 to $1,500 per mile of road 15 ft. wide.

The cost of applying a 4 or 5-in. layer of clay or loam that may be secured within one mile of the road, and mixing it with the sand, will be about the same. It is generally recognized that the mixture of sand and clay is more serviceable than the mixture of oil and sand.

**The Cost of Surface Oiling.**—It is very difficult to report any definite cost data on this work because every job varies considerably due to local conditions. The State Highway Department has superintended the letting of contracts for oiling earth roads at a cost of 6 to 8 ct. per gallon, including all work. On state aid earth road oiling, prices have varied from $450 to $600 per mile, which includes the oiling of a width of 15 ft., ½-gal. treatment in two applications. In general the cost of preparing a public road for an oil treatment may vary from $100 to $2,000 per mile. However, the grading and preparation of an earth road should not be charged against the cost of oiling. The oiling or dragging of an earth road is a maintenance proposition and should be estimated separately from the building or preparing of the road. The road should be kept well shaped regardless of whether it is to be oiled or not. However, some cleaning is almost always necessary prior to the first application of oil, and this cost will vary from $25 to $50 per mile of road.

Road oil can be purchased for from 3 to 7 ct. per gallon, depending upon the quality. It may be applied on the surface of the road at the rate of ¼ to ½ gal. per square yard. So the cost of oil alone may vary from $75 to $275 per mile of road 15 ft. wide, depending upon the quality and quantity of oil applied.

The cost of applying the oil will vary, depending upon the length of haul and the kind of equipment used. This cost may be estimated at from $50 to $150 per mile of road 15 ft. wide.

The above figures show the cost of oiling to vary from $150 to $475 per mile of road. With average conditions and with a medium priced oil, the average cost of oiling alone per application may be from $200 to $250 per mile of road 15 ft. wide. These costs are based on the conditions prevailing during the season of 1915. The above figures are only an approximate estimate, and are based on the best information available in this and other similar states.

Some experiments have been made along the line of thoroughly saturating the top 6 in. of earth and then compacting it with a petrolithic roller. The saturating of the earth with the first application of 2½ to 3 gal. of oil was intended to resemble somewhat the continual oiling of the surface over a period of four or five years. The experiments referred to were made in 1908 and 1909 on three different sections of road of ½ to ¾ mile in length. Two of the sections were considered failures and were within three years covered with a more desirable wearing surface. The third section still remains; however, it shows very few signs of having such a treatment. This section seems to rut in the winter and spring almost as badly as the other portion of the road; in midsummer the surface of the road pulverizes and forms a dust that flies almost the same as dust from other portions of the road.

In view of all the information that is available on oiled earth roads, indications are that the treatments must be made each year or at least every other year to get the desired results. On this basis, $150 to $200 per year for five or ten years may be a basis for estimating the cost of surface oiling.

**Quality of Oil.**—On practically all work that has been done in the past, a light oil with a paraffin or semi-asphaltic base has been used. There is very little information available on the use of the higher grades of asphaltic oil on earth roads. It is predicted by our best authorities that the use of the higher grade asphaltic oils will prove to be more satisfactory and more economical in the end than the use of inferior products.

It seems to be the unanimous opinion of all extensive users of road oils that the semi-asphaltic products are far superior to the paraffin oils. The best products are secured only by purchasing the material under carefully drawn specifications and using the same under the approval of a competent chemist.

The amount of asphalt or residue that a product may contain does not classify it as a suitable material for the road under consideration. For instance, a thick, heavy material with 40 per cent asphalt or residue will not give the same results as a light, thin product of the same asphaltic content.

The purpose of oiling an earth road is the suppression of dust and the waterproofing of the surface. It is evident, therefore, that the best results may be secured during the first application by applying either a cold oil or at least a very thin product that will penetrate the surface of the road several inches and at the same time contain as many binding elements as possible so as to seal all pores in the earth, making it waterproof and at the same time adding some binding qualities that may assist the bond of the soil itself. A suitable product, as is commonly expressed, may vary from 30 to 60 per cent in asphalt. After the surface of the road has been thoroughly saturated, a hot oil or a slightly heavier product may be used.

If the heavier oils are used for the first application they will not readily penetrate the surface of the road and will consequently form a mat on top. The forming of the mat before the surface of the road is more or less waterproof may be a serious fault as moisture will accumulate beneath the mat and the road will be much slower in drying out than it would had the oil not been applied. The mat surface with a soft subsoil will rut more readily, besides breaking and scaling off in large pieces, making the road surface rough and undesirable.

The paraffin oils are ordinarily thin and light, yet they do not contain sufficient binding elements to seal and hold the surface of a road. Such oils after being in use a short while apparently have very little value, as they permit the surface of the road to grind up into a light oil-mixed powder, which makes a slick, slimy mud when wet, and which, when dry, flies almost as readily as the ordinary dust.

### Illinois Specifications for Oiling Earth Roads.

The specifications of the Illinois State Highway Department for surface oiling earth roads, and for the oils, are as follows:

### Surface Oiling Earth Roads.

Preparation of Earth Road Surface.—The earth road surface shall be smooth, free from sod, vegetation, loose material or other foreign matter and shall conform to the cross section shown on the plans. It shall be compacted with a tractor or a power roller that weighs at least 300 lb. per inch of width of tread of one wheel; and the compacted surface shall be smooth and free from waves. The surface shall also be free from dust and sufficiently dry to prevent the wheels of the oil distributor from sticking or marring the surface.

If the surface of the road is rutted in any manner or is dug out into holes or depressions that would retain water, it shall be made perfectly smooth by dragging at suitable times prior to the application of the oil.

Application of Oil.—Oil shall not be applied upon the road until after the surface has been approved by the engineer. The oil shall be distributed uniformly over the width of road specified. It shall be applied by a pressure distributor under not less than 15 lb. pressure per square inch. The distributor shall be regulated so that the width to be oiled shall be covered by one, two or more equal strips without overlapping. Extreme care shall be taken to get the oil uniformly distributed. All places not covered by the first application of oil shall be covered by hand-pouring cans which shall follow immediately behind the distributor.

The oil shall be applied in at least two applications. The total quantity of oils used shall be not less than ½ gal. per square yard of surface specified to be oiled. Whether applied in two applications or more, the amount of oil for each application shall be the same, and there shall be a period of at least six hours intervene between successive applications or such additional time as is necessary for the oil to be absorbed and offer no tendency to stick to the wheels. From the time of the first application of oil until three days after the last application, the road shall be kept closed to all public travel. Oil applied on days having an air temperature of less than 75 degrees F., and oil that is too heavy to penetrate readily into the surface of the road, shall be heated to the temperature prescribed by the engineer before applying same.

Sampling Oil.—A one-quart sample of the oil will be taken by the engineer from each car immediately upon the arrival of same at destination. The sample will be securely labeled, bearing the contractor's name and address and also the County, Route and Section of the road. Attached to the package there shall be a stamped and addressed letter giving the name of the contractor and also his postoffice and telegraph address, in addition to the trade name of the product and the company selling same. The package shall be addressed to the State Highway Department, Testing Laboratory, 820 East Adams Street, Springfield, Illinois. As soon as possible after the receipt of sample at laboratory, the material will be tested and reported.

Testing Oil.—No oil shall be used until after having been tested and approved by the engineer.

SPECIFICATIONS—"A." OIL FOR SURFACE TREATMENT OF EARTH ROADS (COLD APPLICATION).

1. The oil shall be a fluid product, free from water.

2 Specific Gravity. Its specific gravity at 25° C. (77° F.) shall not be less than 0.910 (23.8° B.).

3. Total Bitumen. It shall be soluble in chemically pure cold carbon disulphide to the extent of at least 99.5 per cent.

4. Naphtha Insoluble Bitumen. Of the total bitumen not less than 5.0 per cent by weight shall be insoluble in 86° B. paraffin naphtha at air temperature.

Fixed Carbon. The fixed carbon shall not be less than 4.0 per cent.

6. Viscosity. When 240 c.c. of the oil is heated in an Engler Viscosimeter to 50° C. (122° F.) and maintained at this temperature for 5 minutes, the first 50 c.c. which flows through the aperture shall show a specific viscosity of not less than 5.0 nor more than 20.0.

7. Loss on Evaporation. When 20 grams of the oil (in a tin dish 2½ in. in diameter and ¾ in. deep, with vertical sides) is maintained at a temperature of 163° C. (325° F.) for 5 hours in a N. Y. Testing Laboratory oven, the loss shall not exceed 25 per cent by weight.

SPECIFICATIONS—"B." LIGHT OIL FOR SURFACE TREATMENT OF EARTH ROADS (COLD APPLICATION).

1. The oil shall be a fluid product, free from water.

2. Specific Gravity. Its specific gravity at 25° C. (77° F.) shall not be less than 0.890 (28.3° B.).

3. Total Bitumen. It shall be soluble in chemically pure cold carbon disulphide to the extent of at least 99.5 per cent.

4. Viscosity. When 240 c.c. of the oil is heated in an Engler Viscosimeter to 50° C. (122° F.) and maintained at this temperature for 5 minutes, the first 50 c.c. which flows through the aperture shall show a specific viscosity of not less than 5.0 nor more than 20.0.

5. Residue on Evaporation. When 30 grams of the oil (in a tin dish 2½ in. in diameter and ¾ in. deep with vertical sides) is evaporated until a residue of a penetration at 25° C. (77° F.) of 10 millimeters is obtained (when tested with Dow machine, No. 2 needle, 100 grams, 5 seconds), the weight of the residue shall be at least 10 per cent of the weight of the oil taken for evaporation. At no time during this evaporation shall the oil be heated at a temperature to exceed 250° C. (482° F.).

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## ROAD FUNDS FROM MOTOR CAR REGISTRATIONS.

Over $16,000,000 was obtained for road work in 1915 from revenues derived by the state governments for registration of motor cars, including commercial vehicles. According to a recently issued circular prepared by the Division of Road Economics of the U. S. Office of Public Roads, during the past 10 years the state registration of motor cars, including commercial vehicles, has increased 5,000 per cent or from about 48,000 in 1906 to 2,445,664 in 1915. In 1906 less than 3/10 of 1 per cent of the total rural road and bridge expenditures in the United States was derived from the motor-vehicle revenues, while nearly 7 per cent was secured from this source in 1915.

The total amount collected by the various states in 1905 amounted to only $62,500. At that time only a few of the states made the revenues from this source directly applicable to road work. During 1915 the total gross revenues derived from the registration of motor vehicles and the licensing of operators, chauffeurs, dealers, etc., amounted to $18,245,713. Nearly all the states now apply the motor-vehicle revenues directly to the construction, improvement, or maintenance of the public roads. Of the total revenue collected during 1915 practically 90 per cent was applicable to road work, and of this slightly over 70 per cent was placed more or less directly under the control and supervision of the state highway departments.

The number of motor vehicles registered under the general designation of automobiles, motor trucks, and commercial vehicles in continental United States during 1915 amounted to a total of 2,445,664. The total road mileage of the United States outside of the incorporated towns and cities is approximately 2,375,000 miles. There is, therefore, an average of slightly more than 1 motor car for each mile of rural public road in the United States. The distribution of the motor cars among the several states, however, is far from uniform. There is only 1 motor car for every 6 miles of rural road in the state of Nevada, while in the state of New Jersey there are nearly 6 motor cars for every mile of such road. Or, with an average of 1 motor-car registration for every 44 persons in the United States, in the state of Iowa there is 1 for every 16 persons, but only 1 for every 200 persons in the state of Alabama.

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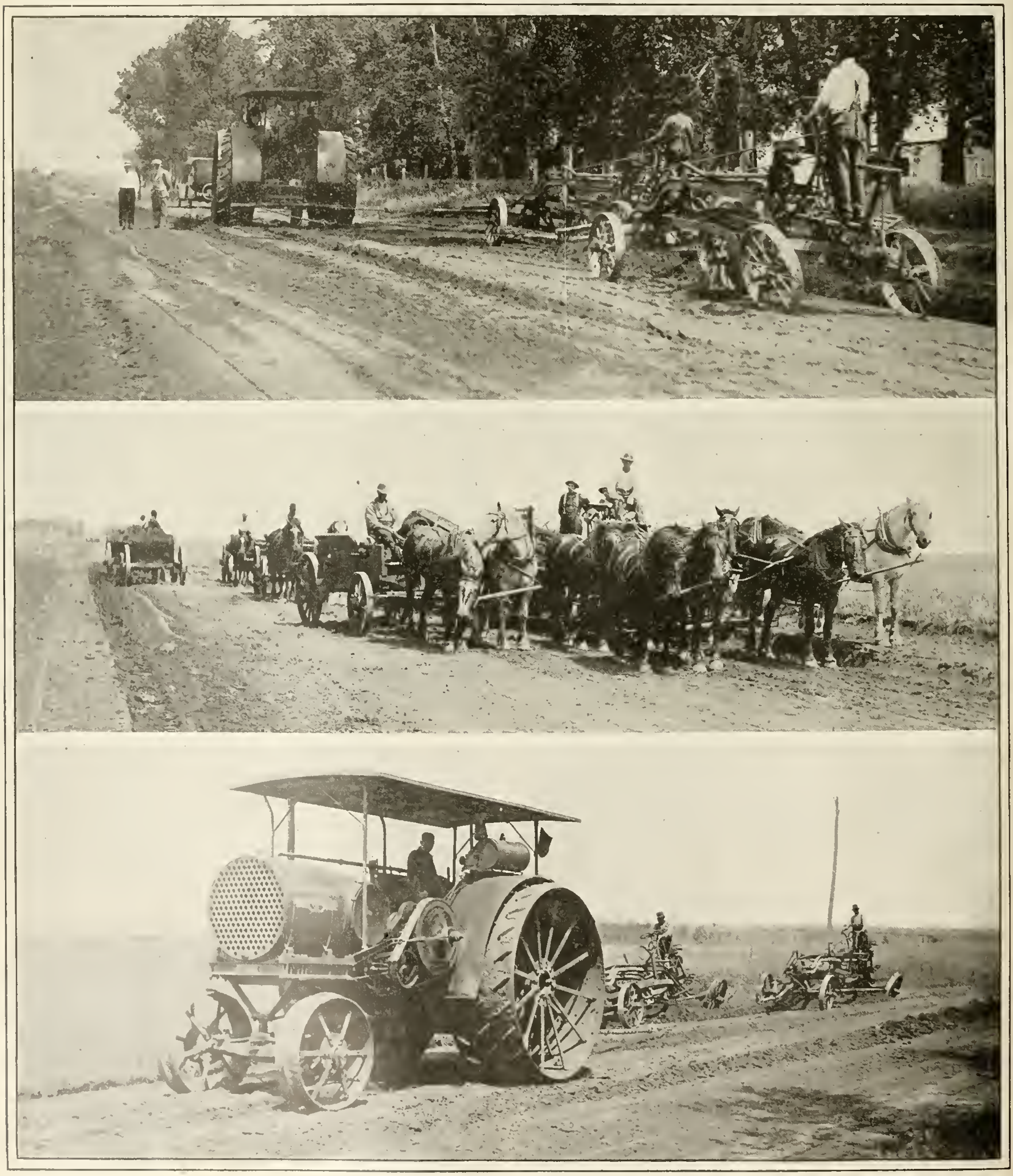
## EARTH ROAD CONSTRUCTION IN MURRAY COUNTY, MINNESOTA.

Earth road construction in Murray County, Minnesota, is carried out by day labor, using the county outfit. The plan was adopted in 1915 and during that year 45 miles of road were built. It is expected to build 55 miles this season with the same outfit. The work is in charge of P. L. Minder, District Engineer of the State Highway Commission. The following description of the Murray County system has been prepared from a paper read by Mr. Minder this spring before the Minnesota Engineers' and Surveyors' Society, and from additional information furnished by him:

For the 1915 work thirty-six head of horses for the season were hired from an out of town contractor at 50 ct. a day per head. Ten dump wagons, 4 fresnos, 2 lumber wagons, 2 plows, 1 mormon scraper, 2 leaning wheel 12-ft. graders and the camp outfit were bought. There already were several elevating graders in the county which were sufficient for the needs. The total cash outlay at the start was approximately $3,500.

In hiring 18 teams it was assumed that on a long haul all ten wagons could be used. There then would be 6 teams for the elevating grader, 10 teams for the wagons, 1 team for the mormon scraper and 1 team to haul supplies and culverts. When the haul shortened the teams that were not needed on the wagons were put on the fresnos for short hauls and side borrow, or for hauling culverts. The extra men that were taken off the fresno outfit when it was not working were used to put in culverts. In this way it was possible to keep every man and team busy without any lost time.

It is a noticeable fact that many contractors spend most of the profits they make in grading on finishing the road. Most of them having been railroad contractors, rough in several miles of road and then go back and finish, meanwhile the road becomes packed hard and been cut up, and it is much more difficult to finish properly. In order to avoid this costly finishing, the elevating grader was placed in the large cuts, the fresnos following and making the small cuts and doing the side borrow work, if any.



Construction Views of Earth Road Building in Murray County, Minnesota.

As soon as a mile had been roughed in, keeping the road fairly even with a mormon scraper, the engine and the two 12-ft. graders followed, doing the turnpiking and finishing on that mile. By this procedure the cost of finishing was never more than $20 a mile.

In 1914 the contract for grading was let at 25 ct. per cu. yd. and for turnpiking at 5 ct. per lin. ft. The cost to the contractor was 33 ct. per cu. yd. for the grading and 7 ct. for the turnpiking, resulting in a loss to him of about 33 per cent. His costs did not cover engineering, supervision and surveying. Last year doing the work by day labor the average costs, including engineering, construction superintendence, depreciation of outfit, and, in fact, everything chargeable against the building of roads, was 19 ct. for the grading and 2½ ct. for the turnpiking, which was 70 per cent of the 1914 contract and 55 per cent of the contractor's cost of doing only the actual construction work in 1914.

The season of 1915 was very wet, but only two days were lost, exclusive of the time it was actually raining, and this was due to the fact that the outfit had just finished a job and it was too wet to move to a new location. Loss of time was avoided by pitching camp on a mile of heavy work, which was done during wet weather and at odd times when it was impracticable to go far from camp. In order to start road building early in the spring, work is started on high ground and in the sandy portions, if there are any, so that the wet weather does not hinder greatly.

No local teams whatever were used on the job, and but one local man stayed during the entire season. Several of the local men were tried at the start, but were found unsatisfactory. So all of the men were gotten out of town and only those were employed who were experienced in railroad grading. These men quickly adapted themselves to road grading methods. All experienced men, exclusive of the one-up teamsters, were hired with the understanding that they were to stay the entire season at a certain rate. If they did not remain their wages would be less. This was found to be a very satisfactory arrangement, all these men staying the entire season and are returning this season.

In the buying of feed a considerable sum can be saved by looking up grain and hay in the several districts where there is work to do. If the hay is scarce, and there is liable to be a shortage during the summer, it is a good idea to buy up the hay early in the season. Oats can be bought much cheaper from the farmer than from the elevator, because of the elimination of the hauling expense and the elevator company's profit.

The cooking outfit was bought by the county, but arrangements were made with a cook to furnish board for the men at $5.00 a week. In return for the use of the outfit he furnished board for the two foremen. In two seasons of 7 months each this board would amount to $560, which is more than the cost of the outfit. The terminating of this contract was left to the option of a county, thus insuring good board for the men, it being necessary to the retention and efficiency of the men that they be well fed. The cook made good wages during the season, doing all the work himself. If a cook had been hired by the month the county would have had to furnish a flunkey, and there would have been more waste.

An elaboration of this organization is being considered by the township officers of Murray County at the present time. Under the plan as at present set forth, each township is to put in $2,000 into a construction fund to be used solely for the construction of roads, these roads to be built in continuous sections in each township. The maintenance of these roads is to be taken care of by the individual townships themselves.

The twenty townships of the county are to be divided into two groups of ten each, having one outfit for each group. This will make a construction fund of $20,000 for each group. Out of this fund it is planned to buy 10 dump wagons, two 12-ft. blade graders and the camp outfit for each group.

The work is to be distributed as uniformly as practicable over the ten townships, and at the close of the season each township is to be charged for the cost of the work done within its limits and its proportion, or 10 per cent, for the cost of the equipment. Then the balance of the $20,000, if any, is to be refunded to that township. The administrating and engineering is to be under the direct charge of the District Highway Engineer.

The organization and wages of the county road force is as follows:

Highway engineer acting as Superintendent and Engineer.
Foreman, $125 per month.
Elevating grader man, $75 per month and board.
Elevating grader driver, $60 per month and board.
Push cart driver, $45 per month and board.
Dump man, $3.25 per day.
Wagon teamsters, $40 per month and board.
Mormon Scraper teamster, $40 per month and board.
Laborer taking rock out of cuts, $2.50 per day.

The above outfit is handled by the general foreman. The number of teams on the wagons varies with the length of haul. The teams not needed on wagons are put on fresnos. The output of this oufit varies from 600 to 900 yd. per 10-hour day, or an everage of 750 yd. a day.

The following outfit is used when the elevating grader outfit is on a short haul and is under the straw boss:

Straw boss, $75 per month and board.
Four-horse fresno teamsters, $45 per month and board.
Plow team teamster, $40 and board.
Two laborers, $2.50 per day.

This outfit is used solely for side borrow work or taking out cuts of less than 100 yd. The output of this outfit is approximately 200 yd. a day, but is very hard to gage on account of varying class of work they do.

The following outfit is handled by the head grader man and will average one mile of finished road every two working days:

One 30-60 HP. engine and man, $30 per day.
2-blade grader men at $60 per month and board.

When the straw boss and his outfit is not working he and the laborers put in sectional concrete pipe.

In the maintaining of roads a 12-ft. blade grader and a small engine is kept on the road continually cleaning ditches and cutting off the shoulders of the road left by the drags.

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## THE $85,000,000 FEDERAL AID ROAD BILL AND APPORTIONMENTS FOR FIRST YEAR.

The Federal Aid Road Bill, signed by President Wilson on July 11, provides $85,000,000 for highway construction purposes during the next 5 years. Of this total $10,000,000 is to be expended for the survey, construction and maintenance of roads and trails within or partly within the National Forests. This last appropriation will not be available except upon a co-operative agreement made between the state, territory or county and the Secretary of Agriculture. It also is provided that the aggregate expenditures in any state, territory or county shall not exceed 10 per cent of the value, as determined by the Secretary of Agriculture, of the timber and forage resources which are or will be available for income upon the National forest lands within the respective county or counties wherein the roads or trails will be constructed.

Of the $75,000,000, the sum of $5,000,000 will be available for the fiscal year ending June 30, 1917; $10,000,000 for 1918, $15,000,000 for 1919, $20,000,000 for 1920 and $25,000,000 for 1921. Of these sums 3 per cent is to be withheld for Federal administrative expenses.

The allotments of the Federal fund to the several states will be made by the Secretary of Agriculture in this manner: One-third in the ratio which the area of each state bears to the total area of all the states; one-third in the ratio which the population of each state bears to the total population of all the states, as shown by the latest available Federal census; one-third in the ratio which the mileage of rural delivery routes and star routes in each state bears to the total mileage of rural delivery routes and star routes in all the states, at the close of the next preceding fiscal year, as shown by the certificate of the Postmaster General. None of this money can be used except a state contributes at least an equal amount for the road on which it is to be applied.

In order to obtain federal aid, the state authorities

TABLE I.—APPORTIONMENT OF FEDERAL ROAD FUNDS FOR FISCAL YEAR 1917.

| State. | Area as of 1910 United States census. |  | Population as of 1910 United States census. |  | Star and rural routes shown by certificate of Postmaster General as of June 30, 1916. |  | Percentage apportionment. | Sum apportioned. |
|---|---|---|---|---|---|---|---|---|
|  | Square miles. | Percentage. | Population. | Percentage. | Miles. | Percentage. |  |  |
| Alabama | 51,998 | 1.71796 | 2,138,093 | 2.33311 | 29,615 | 2.39111 | 2.14740 | $104,148.90 |
| Arizona | 113,956 | 3.76500 | 204,354 | .22299 | 3,096 | .24997 | 1.41265 | 68,513.52 |
| Arkansas | 53,335 | 1.76214 | 1,574,449 | 1.71806 | 20,215 | 1.63158 | 1.70493 | 82,689.10 |
| California | 158,297 | 5.22999 | 2,377,549 | 2.59441 | 18,823 | 1.51976 | 3.11472 | 151,063.92 |
| Colorado | 103,948 | 3.43435 | 799,024 | .87191 | 10,781 | .87045 | 1.72557 | 83,690.14 |
| Connecticut | 4,965 | .16404 | 1,114,756 | 1.21641 | 6,721 | .54265 | .64104 | 31,090.44 |
| Delaware | 2,370 | .07830 | 202,322 | .22078 | 2,566 | .20718 | .16875 | 8,184 37 |
| Florida | 58,666 | 1.93827 | 752,619 | .82127 | 8,706 | .70292 | 1.15415 | 55,976.27 |
| Georgia | 59,265 | 1.95806 | 2,609,121 | 2.84711 | 43,397 | 3.50386 | 2.76968 | 134,329.48 |
| Idaho | 83,888 | 2.77158 | 325,594 | .35529 | 7,594 | .61314 | 1.24667 | 60,463.50 |
| Illinois | 56,665 | 1.81216 | 5,638,591 | 6.15290 | 69,860 | 5.64048 | 4.55518 | 220,926.23 |
| Indiana | 36,354 | 1.20110 | 2,700,876 | 2.94723 | 52,619 | 4.24844 | 2.79892 | 135,747.62 |
| Iowa | 56,147 | 1.85505 | 2,224,771 | 2.42770 | 58,943 | 4.75904 | 3.01393 | 146,175.60 |
| Kansas | 82,158 | 2.71442 | 1,690,949 | 1.84518 | 53,240 | 4.29858 | 2.95273 | 143,207.40 |
| Kentucky | 40,598 | 1.34132 | 2,289,905 | 2.49877 | 27,113 | 2.18910 | 2.00973 | 97,471.94 |
| Louisiana | 48,506 | 1.60259 | 1,656,388 | 1.80747 | 9,458 | .76364 | 1.39123 | 67.474.66 |
| Maine | 33,040 | 1.09161 | 742,371 | .81608 | 13,566 | 1.09531 | .99900 | 48,451.50 |
| Maryland | 12,327 | .40727 | 1,295,346 | 1.41350 | 11,194 | .90380 | .90819 | 44,947.22 |
| Massachusetts | 8,266 | .27310 | 3,366,416 | 3.67347 | 7.698 | .62153 | 1.52270 | 73,850.95 |
| Michigan | 57,980 | 1.91561 | 2,810,173 | 3.06650 | 49,981 | 4.03545 | 3.00585 | 145,783.72 |
| Minnesota | 84,682 | 2.79782 | 2,075,708 | 2.26504 | 46,384 | 3.74503 | 2.93596 | 142,394.06 |
| Mississippi | 46,865 | 1.54838 | 1,797,114 | 1.96103 | 24,646 | 1.98991 | 1.83311 | 88,905.84 |
| Missouri | 69,420 | 2.29357 | 3,293,335 | 3.59373 | 57,108 | 4.61088 | 3.49939 | 169,720.41 |
| Montana | 116,997 | 4.85664 | 376,053 | .41035 | 10,065 | .81264 | 2.02654 | 98,287.19 |
| Nebraska | 77,520 | 2.56119 | 1,192,214 | 1.30096 | 33,964 | 2.74224 | 2.20146 | 106,770.81 |
| Nevada | 110,690 | 3.65710 | 81,875 | .08934 | 2,935 | .23697 | 1.32780 | 64,398.30 |
| New Hampshire | 9,341 | .30862 | 430,572 | .46985 | 6,444 | .52029 | .43292 | 20,996.62 |
| New Jersey | 8,224 | .27171 | 2,537,167 | 2.76859 | 7,708 | .62234 | 1.22088 | 59,212.68 |
| New Mexico | 122,634 | 4.05171 | 327,301 | .35715 | 5,716 | .46151 | 1.62346 | 78,737.81 |
| New York | 19,204 | 1.62565 | 9,113,614 | 9.94489 | 48,773 | 3.93792 | 5.16949 | 250,720.27 |
| North Carolina | 52,426 | 1.73211 | 2,206,287 | 2.40753 | 36,358. | 2.93553 | 2.35839 | 114,381.92 |
| North Dakota | 70,837 | 2.34039 | 577,056 | .62969 | 21,548 | 1.73978 | 1.56996 | 76,143.06 |
| Ohio | 41,040 | 1.35592 | 4,767,121 | 5.20194 | 61,968 | 5.00328 | 3.85372 | 186,905.42 |
| Oklahoma | 70,057 | 2.31462 | 1,657,155 | 1.80831 | 37,145 | 2.99908 | 2.37400 | 115,139.00 |
| Oregon | 96,699 | 3.19485 | 672,765 | .73413 | 11,621 | .93828 | 1.62242 | 78,687.37 |
| Pennsylvania | 45,126 | 1.49092 | 7,665,111 | 8 36126 | 54,638 | 4.41146 | 4.75555 | 230,644.17 |
| Rhode Island | 1,248 | .04123 | 542,610 | .59210 | 1,093 | .08825 | .24053 | 11,665.71 |
| South Carolina | 30,989 | 1.02385 | 1,515,400 | 1.65362 | 21,851 | 1.76424 | 1.48057 | 71,807.64 |
| South Dakota | 77,615 | 2.56433 | 583,888 | .63715 | 22,362 | 1.80550 | 1.66899 | 80,946.02 |
| Tennessee | 42,022 | 1.38837 | 2,184,789 | 2.38407 | 40,731 | 3.28861 | 2.35368 | 114,153.48 |
| Texas | 265,896 | 8.78496 | 3,896,542 | 4.25195 | 62,181 | 5.02048 | 6.01913 | 291,027.81 |
| Utah | 84,990 | 2.80799 | 373,351 | .40740 | 3,806 | .30730 | 1.17423 | 56,950.15 |
| Vermont | 9,564 | .31599 | 355,956 | .38842 | 8,777 | .70865 | .47102 | 22,844.47 |
| Virginia | 42,627 | 1.40836 | 2,061,612 | 2.24966 | 31,045 | 2.50556 | 2.05486 | 99.660.71 |
| Washington | 69,127 | 2.28389 | 1,141,990 | 1.24615 | 11,350 | .91640 | 1.48215 | 71,884.28 |
| West Virginia | 24,170 | .79855 | 1,221,119 | 1.33250 | 14,417 | 1.16402 | 1.09836 | 53,270.46 |
| Wisconsin | 56,066 | 1.85237 | 2,333,860 | 2.54674 | 43,854 | 3.54076 | 2.64662 | 128,361.07 |
| Wyoming | 97,914 | 3.23499 | 145,965 | .15928 | 4,844 | .39110 | 1.26179 | 61,196.82 |
| Total | 3,026,719 | 100.00000 | 91,641,197 | 100.00000 | 1,238,548 | 100.00000 | 100.00000 | 4,850,000.00 |

designated in the act must submit to the Secretary of Agriculture a statement of the projected road construction, which must be "substantial in character," in which national assistance is desired. If the Secretary approves a project, the state authorities must then submit such surveys, plans, specifications and estimates as he may require. If these engineering and legal features are approved by the Secretary, the state officials are at liberty to go ahead with the work.

The Treasury Department will pay to the proper state officials from time to time, as the Secretary of Agriculture directs, the federal share of the cost of the work, not to exceed $10,000 per mile, which has been inspected and approved by him. This share must not exceed half the cost.

The construction work in each state is to be done in accordance with the laws of the state and under the direct supervision of the state highway department, subject, however, to the inspection and approval of the Secretary of Agriculture without which the state cannot share in the apportionment of the Federal appropriation.

The law requires the states or their civil subdivisions to maintain the roads built with federal assistance. If needed repairs are not made and the surface preserved in a reasonably smooth condition, considering the type of construction, the Secretary of Agriculture must notify the state authorities of the fact, and if the road has not been put in proper condition within four months from the receipt of that notice, the Secretary is directed to disapprove any further road project from that state or its civil subdivision, until the road has bgen put in satisfactory condition.

The factors of apportionment to states under the Federal Aid Roads Act appropriation for the fiscal year 1917 are shown in Table I.

## RESURFACING OLD BELGIAN BLOCK PAVEMENTS WITH BITUMINOUS SURFACE.

During 1915 the city of Atlanta, Ga., resurfaced several old Belgian block pavements with sheet asphalt. Lutz surface heating machines were used to heat the old pavement sufficiently to completely dry it and to cause a bond between an application of asphaltic binder coat. The following description of the work is taken from a paper by A. P. McClellan in the recently issued Proceedings of the Engineering Association of the South:

A sheet asphalt wearing surface was applied on an old Belgian block pavement on Gilmer St. from Edgewood Ave. to Washington St.

As there was a street railway track on this section, it was necessary to lower the block in the direction of the rail toward the curb for a sufficient distance to get approximately 1½-in. depth to the asphaltic wearing surface. The blocks were taken out and the sub-grade lowered and blocks were relaid and rammed.

Following this, the entire street surface was cleaned and, with the use of a fire hose, the joints were washed out for a depth of approximately 2½ in. Next, the surface heater was applied and the blocks were heated until thoroughly dry. It was intended to heat the blocks to about a maximum temperature of 250° F. sufficient time to drive out the moisture in the blocks and the joints and to open the pores in the blocks.

Immediately following the heater a binder coat of bitumen was applied to the heated blocks. Next an average depth of 2 in. of standard sheet asphalt mixture was applied in the usual manner. Inside the rail, the blocks on this particular section were not lowered. The joints were cleaned as outside the track, and a standard sheet asphalt mixture was applied to a depth of 1½ in. in the center of the tracks tapering down to the head of the rail.

This section of pavement so far is in fairly good condition, showing slight indications of fracture along that part inside the tracks.

It is not believed that this method of construction will stand inside street railway tracks in constant service. This particular section of track, however, is not in use except during the grand opera season and during large conventions.

The cost of the work on Gilmer St. was as follows:

Total cost of resurfacing, including royalty, 69.42 ct. per surface yard:

Itemized cost.

| | Per sq. yd.<br>Cts. |
|---|---|
| Resetting blocks | 8 |
| Heater, royalty, and fuel only | 7 |
| Labor | 19 |
| Materials | 38.4 |
| Total | 69.4 |

The next application was on Piedmont Ave. from Ponce de Leon Ave. north to Sixth St. This street carries a double line of surface railway tracks, part of which have a grooved rail section and part of which has a "T" rail section. This work was done during very bad weather in the fall of 1915, and the operation was similar to that on Gilmer St., except that the blocks were lowered approximately 2 in. across the entire track area. After cleaning the joints and applying the surface heater, followed by the binder coat, which at the time of application showed splendid adhesion to the granite, several days of rainy weather were encountered, which caused the binder course over which the asphalt had not been laid, to lose its bond to the block. Strips of this binder could be pulled up without trouble. It was necessary, on a part of this street, to reapply the binder coat. On this work, except adjoining the rail, at the present time, the surface is in good condition with the exception of a slight and almost imperceptible wave along the west side of the street for a distance of about 200 ft.

Along the grooved section of rail a straight fracture against and paralleling the rail developed almost immediately after laying and is showing slowly increasing width due to vibration of the rail, which is causing a gradual separation of the mineral aggregate from the bitumen.

Along the "T" rail section the asphalt is showing marked signs of deterioration following the immediate fracture along and paralleling the rail as was the case in the grooved rail section. At some places along the "T" rail the asphalt has raveled for a distance of 8 in. away from the rail, the raveling thus allowing the admission of water, and undoubtedly will continue to disintegrate the asphalt. It is not known whether this marked disintegration adjoining the "T" rail section is due in any way to the type of rail or is due to the fact that along this rail, in rolling, it was practically impossible to get good compression, owing to the fact that the roller would mount the rail and the curvature of the pavement prevented good compression adjoining the rail.

The entire cost per square yard, including royalty, on this work was 73.3 ct. The cost sub-divided is as follows:

| | Per sq yd.<br>Cts. |
|---|---|
| Labor | 32.5 |
| Material | 33.0 |
| Heating, fuel | 2.6 |
| Heating, royalty | 5.0 |
| Incidentals | 1.1 |
| Total | 73.3 |

Estimated cost of heater application, including royalty, is 20 ct. per surface yard.

## INVERTED CONCRETE PAVEMENT CONSTRUCTION.

An inverted concrete pavement of the type shown in Fig. 1 is used by the Anderson Land Co., of which F. A. Greene, Cedar Rapids, Ia., is chief engineer, for paving for its real estate developments. The depth of the inverted crown, of course, varies according to the amount of surface water to be disposed of. The pavements are 1-course, 6 in. thick, proportioned 1:2½:4 with washed river sand and crushed stone in size from ¼-in. to 1½-in. When no sidewalk is built the grade is carried to the lot grade.

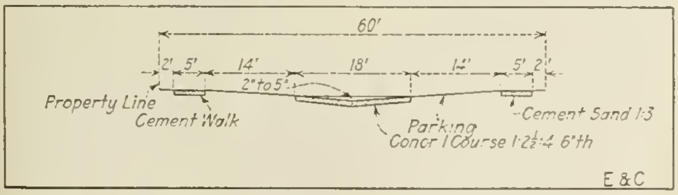


Fig 1—Inverted Concrete Pavement Section.

In surfacing the pavement a dry mix of equal parts of cement and sand is spread lightly over the entire surface and floated several times until the right surface is obtained. The pavements are 18 ft. wide, with expansion joints every 30 ft., using expansion felt joint. No contraction joints nor corrugations of any kind are used, nor are protection plates for the joints employed.

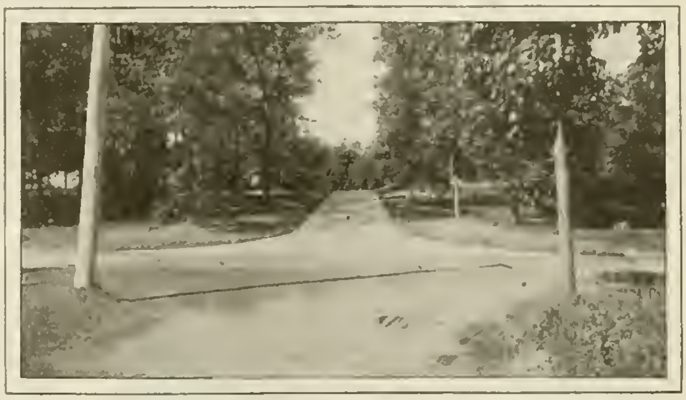
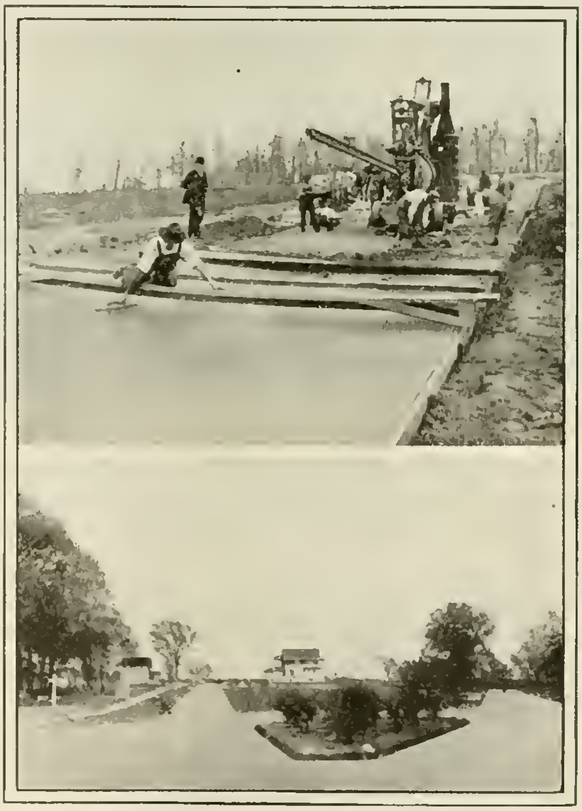


Fig. 2—Connection of Concrete Pavement With Highway.

In constructing this pavement the idea has been to use it in suburban districts or on country roads. Its use is not advocated when curbs are used. On subdivision work, however, it is claimed to give the whole street a symmetrical appearance, and to be highly satisfactory to the residents. Figs. 2, 3 and 4 are views of the concrete pavement construction at Vernon Heights, Cedar Rapids, Ia.

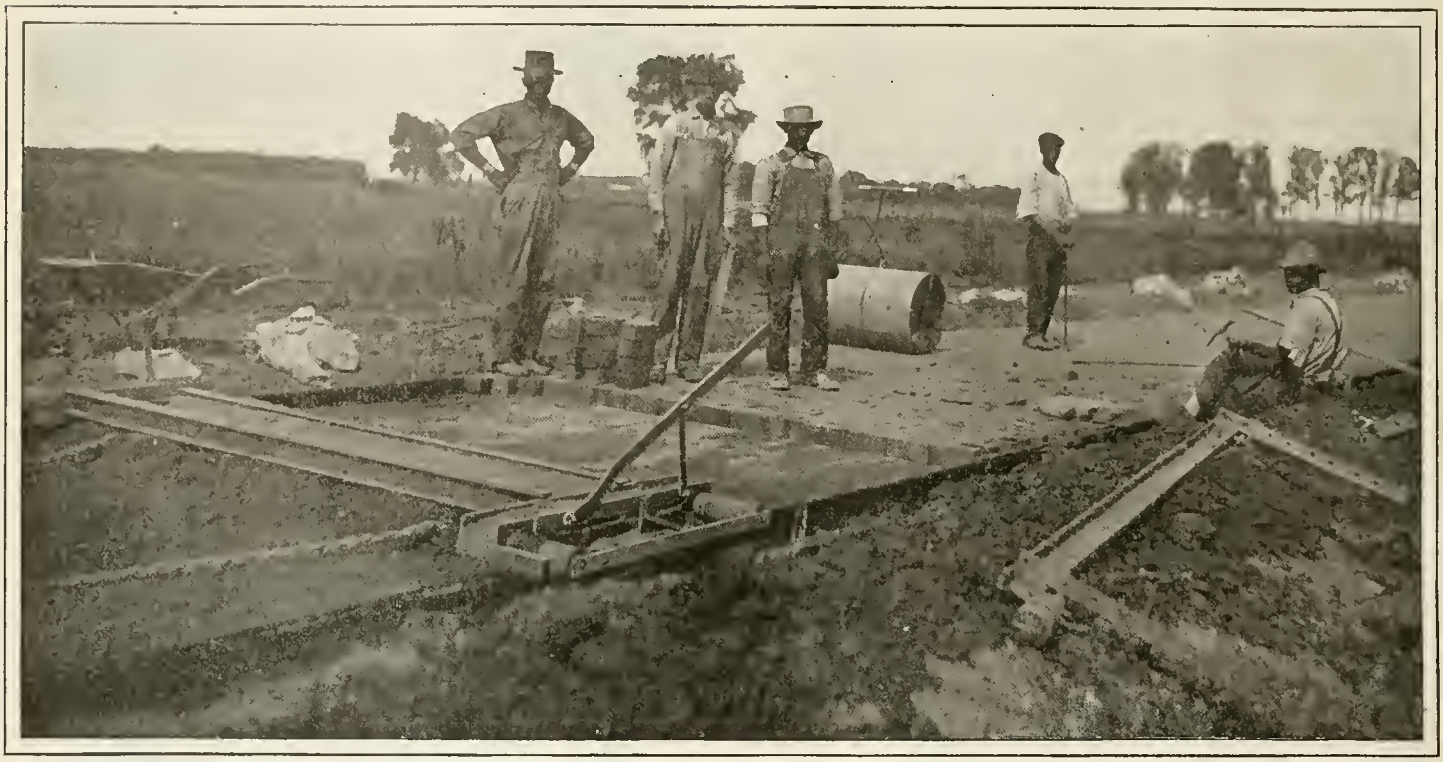


Gigs. 3 and 4—Concrete Pavements at Vernon Heights, Ia.

## TEMPLET FOR MONOLITHIC BRICK PAVEMENT CONSTRUCTION.

The steel template shown in the accompanying illustration has been used with marked success in the construction of monolithic brick pavement in the state of Illinois. The template is constructed of two 5-in. I-beams for the main members, rigidly connected either end by ⅝ by 4-in. iron plates, upon which the roller carriers are mounted and adjusted.

The I-beams are bulldozed to conform to crown requirements or are carried flat, as the case may be. On top of these beams are fastened light 4-in. [ irons to keep any material from overflowing during the movement of the template. The carrier rollers are machined and packed in hard oil and need oiling only once a season. Flanges fastened at the ends of the I-beams have springs and hinges and ride constantly against the forms, thus doing away with all hand luting and leaving a perfect cushion for the brick. These carriers are so made that they are adjustable to any height of brick or depth of cushion, requiring only the loosening of a bolt and set screws to change the adjustment. The heads also are made detachable so that they may be used on any width or several different templates. In operation the space between the two templets is kept filled with dry mortar.



Parrish Templet for Monolithic Brick Pavement Construction.

As the templet is drawn forward by a cable attached to the mixer, the base is struck off to a smooth surface and a layer of dry mortar is distributed evenly over the wet concrete.

This template has been designed and developed by Alan Jay Parrish, general contractor, of Paris, Ill., and has been used by him on his state road contracts. A patent is now pending.

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## PERSONALS.

J. H. Peotrowsky has been appointed Superintendent of Water-Works of Barberton, O.

F. A. Torkelson, formerly City Engineer of Wauwatosa, Wis., has been appointed City Engineer of Green Bay, Wis.

Charles F. Puff has been appointed Assistant Engineer in the Bureau of Surveys, of the Department of Public Works, of Philadelphia, Pa.

E. J. Correll of Chillicothe, O., has been appointed District Engineer, Maintenance of Way of the southwest district of the Baltimore & Ohio Railway.

W. H Bailey, Mechanical Engineer of the Gary works of the Illinois Steel Co., has been promoted to the position of chief engineer of the South Chicago plant.

F. D. Batchellor, District Engineer, Maintenance of Way, Cincinnati, Hamilton & Dayton Railway, has had his jurisdiction extended to include the Northwest District of the Baltimore & Ohio Railroad.

C. H. Howe, Flora, O., has been appointed Division Engineer of the Baltimore & Ohio Railroad, with headquarters at Chillicothe, and C. E. Herty, Seymour, Ind., has been appointed Division Engineer with headquarters at Flora.

George McCormick, heretofore roadmaster on the Marysville Division of the Southern Pacific Railroad, with headquarters at Marysville, has been promoted to position of Assistant Division Engineer, with headquarters at Sacramento, Cal.

Dan W. Thrower, heretofore District Engineer of the Yazoo & Mississippi Valley R. R., with headquarters at Memphis, Tenn., has been appointed assistant valuation engineer for that road and for the Illinois Central R. R., with offices at Chicago.

Stuart K. Knox, M. Am. Soc. C. E., has recently become a member of the firm of Nicholas S. Hill, Jr., and S. F. Ferguson, consulting engineers, New York City. For the past eight years Mr. Knox has been associated with the senior member of the above firm in the capacity of principal assistant engineer. He is a graduate of the University of Michigan.

Peter D. D. Lyall, well-known contractor of Winnipeg, Man., is now lieutenant in the 190th Overseas Battalion of the English army. Lieut. Lyall is a son of the late Peter Lyall, head of one of the largest contracting firms in the Dominion.

J. B. Armstrong, heretofore general manager and chief engineer of the Salt Lake and Utah Railroad, with headquarters at Salt Lake City, Utah, has been appointed Chief Engineer, Maintenance of Way, for the Union Pacific system with headquarters at Omaha.

E. G. Lane has been appointed Engineer, Maintenance of Way of the Western Lines of the Baltimore & Ohio Railroad, with headquarters at Cincinnati, Ohio. Mr. Lane also was appointed Engineer, Maintenance of Way of the Cincinnati, Hamilton & Dayton Railway.

Col. John Millis, U. S. Corps of Engineers, for the past four years in charge of the Newport, Rhode Island, district, has been transferred to Savannah, Ga., where he will be Division Engineer, Southeast Division, and District Engineer of the Savannah District.

H. W. Smith of Kleinfeltersville, Pa., has been appointed general manager of the Philadelphia Construction Co., and will have charge of the management of the Kleinfeltersville and Womelsdorf electric railway now under construction. Mr. Smith formerly was superintendent of the Ephrata and Lebanon Electric Railway and had charge of the construction.

F. D. Nauman, Division Engineer of the Southern Pacific Railway, with headquarters at San Francisco, has been appointed superintendent and chief engineer of the Salt Lake and Utah Railway, succeeding Mr. Armstrong. The duties of general manager of the railway will be performed by President W. C. Orem.

Steps are being taken to effect a permanent organization of city engineers of the State of Washington. A committee of three, of which Hans Mumm, Jr., City Engineer of Everett, Wash., is chairman, has been appointed to prepare a program for a preliminary meeting and a form of organization. D. W. McMorris, in charge of court matters for the Engineering Department of Seattle, Wash., and L. A. Nicholson, City Engineer, of Everett, are members of the committee.

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## OBITUARY.

James Maher, Supt. of Waterworks of Newport, Ky., died recently.

Lloyd C. McCabe, a civil engineer for the Interborough Transit Co., died suddenly July 13, at his home in Brooklyn, N Y., of heart failure.

William R. Patterson, Director of the Western Electric Co., and senior partner of Patterson & Davidson, Consulting Engineers, died July 19, in Chicago.

Ernest G. Barrow, for a number of years city engineer of Hamilton, Ont., died July 20, at Toronto, Ont. Mr. Barrow was a member of the firm of Barrow & Hunting, Contractors.

Charles W. Kirchhoff, Editor of the Iron Age, died July 23, at Asbury Park, N. J., in his 64th year. Mr. Kirchhoff was born in San Francisco in 1853 and attended school in this country and Germany, graduating from the Royal School of Mines, Clausthal, Germany, in 1874. For the following three years he worked as chemist, assayer and assistant superintendent of the Delaware Lead Mills in Philadelphia. In 1877, Mr. Kirchhoff joined the staff of the Metallurgical Review, leaving that publication in the following year for the Iron Age.

L. W. Bierwirth, for many years active in the Engineering and Smokeless Powder Department of the Dupont Company, died July 18 at the University of Pennsylvania Hospital, Philadelphia. He was a graduate of Swarthmore College and entered the employ of the company January, 1899 as an engineer in the black powder department. In 1907 he superintended the construction of the smokeless powder plant which the Dupont Co., at Detroit built for the Brazilian Government, near Rio de Janeiro. On his return to the United States in 1910 he was promoted to be superintendent of the Haskell plant at Haskell, N. J.

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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## CITY WATER FOR IRRIGATION AND ITS POSSIBILITIES.

While making an appraisal of a water works plant in a western city of 15,000 population, the editor was astonished to find a daily water consumption of 600 gal. per capita. The superintendent of the plant was asked why he did not meter the services to reduce water wastage. The reply was that the water was not regarded by him as wasted, for most of it was used to irrigate gardens and lawns.

It was undeniable that this little city, located in an arid region, presents an exceptionally fine appearance. But beside the fine appearance created by its lawns and gardens there is the greater asset resulting from an abundance of fresh vegetables and berries grown in the yards of many of its residents. Doubtless a good deal of water is wasted, but since there is abundance of water delivered through ditches to the reservoir and thence by gravity through pipes to the consumers, the waste is not as yet a serious matter.

The editor remembers his first impression of Salt Lake City when, as a boy, he went there to live 35 years ago. The city seemed like a huge garden in the midst of which lived the gardeners. Water flowed in ditches along the sidewalks of all streets, and each resident had the right, at certain times, to divert some of the ditch water upon the garden in the rear of his house. Large trees grew along the sidewalk ditches. So great was the number of trees and so dense the foliage that when the city was viewed from one of the nearby "benches," or elevated plateaus, it looked like a forest.

Of necessity many of the cities and towns in the arid states have developed in this manner, so that it is taken as a matter of course that city water should be liberally used for garden purposes. But in the rest of America we have a much narrower conception of the possibilities inherent in this use of water. Our narrower conception arises in part from the fact that we often have to pump the water, and in part from the fact that we have sufficient rainfall to make possible the raising of some garden truck without irrigation. We have, therefore, to be taught that the greater productiveness of gardens that are irrigated abundantly justifies irrigation in almost every section of the United States, even where the pumping lift is considerable.

The managers of water works plants have made no effort to teach this fact. Indeed, few of them know it to be a fact. How many city water works men have ever read a single bulletin of the U. S. Department of Agriculture on irrigation? Such literature is for farmers and not for city water works managers, they have thought. But in so thinking they have been wrong, and it is our purpose, in future numbers of this Water Works and Hydraulics monthly issue of Engineering and Contracting, to reprint those parts of the bulletins on irrigation that will demonstrate our contention that nearly every city water works can profitably develop an irrigating load.

We shall show that by the use of overhead sprinkling systems and by the use of water meters to reduce waste, even high priced water may be profitably used for irrigating gardens in cities and villages. Where rainfall is frequent, such an irrigation system will not be called upon to supply great quantities of water save for short periods of drought.

In some cases, if the existing reservoirs are enlarged, or additional reservoirs built, the peak irrigating load can be carried without greatly changing the rest of the water works plant. In other cases it will pay better to install additional pump units to meet the peak demand without resort to storage. Each case presents a different engineering problem, but in every case the fundamental task is to solve the equation so as to give the maximum profit to the water users. This is true even where the water works is privately owned, for when the water user can derive a greater profit from the use of water he is glad to pay to the water works owners a part of his gross gain as recompense for the initiative, intelligence and capital supplied by the owners of the water plant.

## CLEANING UP THE NEPONSET RIVER.

An account of the methods of ridding the Neponset River in Massachusetts of the nuisance arising from the discharging into its waters of sewage and trade wastes is published in another column of this issue. There seem to us to be two good reasons for devoting unusual space to this account. It is presented by an authority in sanitary engineering and having direct and intimate acquaintance with the work. It is a work of sanitation of exceeding interest first because of the detail of the usable information given and second because it exemplifies a character of task that will become increasingly frequent as time goes on. It is not proposed here nor is it necessary to comment on the demonstrated fact that industrial wastes can be so treated as to prevent offensive deposits or odors. We may, however, rightly call attention to the danger of increasing legislation toward making pre-eminent the goal of unsullied natural waters. The uses at large of our natural streams include their use as means of disposing of wastes. Only their use for human consumption and their use for the production of food supply take precedence of their use for waste disposal.

## OPPORTUNITIES FOR ENGINEERS AS WATER WORKS SUPERINTENDENTS.

Due to the "spoils system" in American politics the heads of municipal departments have usually lacked technical training. Often they have had no training at all, save that of the ward politician. Fortunately this state of affairs has been on the mend for several years, but much still remains to be done before the public will universally insist that municipal positions of a technical nature shall be filled by technically trained men.

To those who are at all conversant with the problems of managing a municipal water works, it is apparent that a water works superintendent, to be most efficient, should have a considerable knowledge of engineering. By this we do not imply the necessity of possessing an engineering degree. We do insist that a manager of any plant of an engineering nature, such as a water works, falls short of attainable efficiency unless he is decidedly well versed in the general nature of the technical problems involved in designing and operating the plant. An engineer possessed of executive ability and energy is therefore more likely to make an ideal water works superintendent than an executive lacking engineering knowledge.

The old popular conception of engineering as being purely a process of designing and laying out plants is fast giving way to a broader conception of engineering. Even the present world war is teaching the public that modern battles are mostly won by engineering—the engineering of transportation as well as the engineering of death dealing machinery.

Management engineering, or scientific management, has come to be recognized as a branch of engineering. The publicity that it has received in the last half-dozen years has served to make it easier for engineers to secure managerial positions.

Engineers of all classes are organizing to educate the public as to the efficiency of scientific attack on all problems of industrial and political nature. Engineers in the West and South have thus far led in this movement, but the spread of the propaganda to all parts of America is rapidly taking place. Accordingly there never was more opportune time than the present for organized effort on the part of local engineering associations to secure public approval of methods of lifting such positions as the superintendence of water works out of politics.

If engineering societies and associations, however small, will but go to the public with their facts and arguments favoring civil service examinations for all holders of executive positions in city water, sewer and highway departments, they will meet with a large measure of success. Engineering societies might well offer to conduct the civil service examinations themselves, submitting to the mayor or city commissioners lists of the most satisfactory applicants who have passed the examinations, from which lists of eligibles the mayor or city commissioners would make the final choice.

Incidentally, also, local engineering associations should strive to secure salaries for water works superintendents and others commensurate with the importance of the positions.

## SAVING CITY WATER.

In six continuous weeks less than two inches of rain has fallen in the country around Chicago. Within a ring a few miles wide fringing the city limits are hundreds of acres of truck gardens. Within the city boundaries are thousands of grass plots and beds of flowering plants and thousands of back-yard vegetable patches. All through the city the school children have been allotted vacant lots and encouraged to plant and cultivate them. Traveling to and from business one sees the small people at their work. At the city's doorstep is an inexhaustible lake of water. From it, like arteries, extend conduits carrying the water miles in all directions landward to the very boundaries of the city. But the truck gardens exhibit a stunted vegetation, the grass plots and flower beds present rusty blades and withered blossoms. Because there have been no showers the plants have been deprived of the little water that would have made them flourish and bloom and bear fruit.

Chicago people are large consumers of water. They consume some 200 gal. per person each 24 hours. The managers of the city's waterworks rather deplore these figures. There is wasteful use, they say. They tell at how much less cost they could operate the city pumping plants were the daily consumption as small as it is in many European cities. As far as may be they put restrictions on use of water for irrigating lawns and gardens. They are logical in taking this action. All theory and practice of city water supply supports the principle that water is to be used sparingly. It is a treasure to be hoarded and not a commodity to be distributed in the largest quantities possible. This is not the thought in the supply of the two other commodities almost as universally used—gas and electric current. Their use is encouraged in every way that alert sales managers can devise. And these managers do not encourage waste; they on the contrary spend much money each year in the devising of household appliances to reduce waste. They employ men to visit consumers and instruct them in waste-saving methods of using light and heat and power. And in a decade the unit cost of gas and electric current has decreased to a far greater extent than has the cost of water.

Like gas and electric current, the consumption of water should be encouraged. Its use for lawn sprinkling, for garden irrigation, for every other economic purpose should be increased by all means that the experts can devise. Instead of placing restrictions on consumption to reduce pump installation and pipe line investment, these investments should be enlarged to encourage increased consumption of water. If for six weeks past the clouds had blotted out from Chicago the sunlight no citizen would have gone without the light he needed for his work. For six weeks the sun has driven the rain clouds from the sky and every garden and grass plot and flower bed has withered for want of water.

## A CONSTRUCTION RAILWAY VS. A MOTOR TRUCK ROAD TO THE HETCH HETCHY DAM.

In building the Hetch Hetchy dam for the new water supply for San Francisco, it has been decided by Mr. M. M. O'Shaughnessy, city engineer, that hauling the materials for the dam can be accomplished more cheaply by rail than by motor trucking. But his published estimates of the ton-mile costs by no means convince us that railway haulage is cheaper than motor truck haulage under the given conditions.

It is stated that 225,000 tons of materials must be hauled to the dam a distance of 60 miles, and that a 60-mile railway can be built for $1,665,000, or $27,750 per mile. The cost of operating and maintaining the railway, whose maximum grade is to be 4 per cent, is estimated at 7 ct. a ton-mile. Hence the operating cost of hauling the 225,000 tons 60 miles would be $954,000. About $600,000 of the $1,665,000 invested in the railway roadbed would be subsequently available for a 29-mile stretch of wagon road that must be built anyway, so it is estimated that $1,065,000 represents the value of the railway roadbed that must be charged off against the hauling of the 225,000 tons, making a grand total of $2,019,000 or nearly 15 ct. per ton-mile as the cost of rail haulage.

The shortest haul by wagon roads is 55 miles, and the grades in many places are very heavy. It is estimated by Mr. O'Shaughnessy that motor truck haulage over the existing bad roads would cost 25 ct. per ton-mile, or a grand total of $3,095,000 for motor truck haulage of the 225,000 tons, inclusive of maintenance of the roads. According to Mr. O'Shaughnessy's report:

"It therefore appears that there is a balance in favor of the railroad haul amounting to $1,085,000."

As stated above, these estimates seem to us to be inconclusive, first because no estimate is given of the cost of motor trucking over roads graded and surfaced especially for the job, second because the assumption of 25 ct. per ton-mile is almost double the prevailing contract price of motor trucking over dirt roads in California.

Doubtless Mr. Shaughnessy has data to prove a 25 ct. cost per ton-mile in some given case, but it is rather unsafe to base an estimate for work of this magnitude on any single experience, particularly if that experience was itself based on the performance of only a few trucks under abnormally bad conditions.

Before proceeding to build a million and a half dollar railway to haul less than a quarter of million tons, would Mr. Shaughnessy not be wise to consult the engineers of the California Highway Commission? Would he not be wise also to consult the manufacturers of motor trucks and men experienced in operating trucks? May it not be advisable to build a good road to the Hetch Hetchy dam for permanent use after the dam is finished?

Motor trucking is becoming a specialty and we believe if Mr. Shaughnessy will consult some of the experts on the subject—many of whom are Californians—his plans may be changed entirely.

To mention but one of several feasible plans for greatly reducing the cost of motor-trucking where a large volume of tonnage is to be hauled up steep grades, we may suggest the following: So locate the motor truck road that there will be long stretches of comparatively level road connected by short stretches of very steep road. Provide "pusher" traction engines at each of these steep grades to aid a truck with a trailer.

With a tonnage as large as 225,000 tons to be hauled 55 or 60 miles, it may pay to lay concrete "rails" most of the distance, providing a single track roadway with turnouts at intervals. The "rails" may be two lines of concrete, each 8 in. thick by 24 in. wide, forming a trackway. Upon such a trackway, and with adequate machine shop facilities for keeping the fleet of trucks in repair we believe it may be possible to cut the trucking cost well below 15 ct. per ton-mile, inclusive of the cost of the trackway and the grading therefor.

## WHAT DOES ONE LOOK AT NIAGARA FALLS COST SOCIETY?

In round numbers 3,000,000 horsepower of energy flows to waste at Niagara. At least it would be called waste were it not for the fact that about 1,000,000 people view it annually. This great natural moving picture costs society the value of three annual horsepower per "seat" at the show. If, then, we ascertain the value of a horsepower of waterpower we shall know what it costs society to furnish each visitant one good look at Niagara Falls.

Appraisals of waterpower values have ranged from nil to more than $100 per horsepower. Without going into a careful calculation it may be conservatively estimated that Niagara Falls power is worth to society fully $50 per horsepower per annum. It follows, then, that each observer is indebted to society for $150 every time he visits the great falls.

Is it chimerical to suggest combining ethics and economics? Might not the million annual visitors to this greatest of cataracts secure their thrills at less than $150 per look? Could it not be arranged that for, say, one hour each day the entire volume of water be allowed to flow over the great brink, and for the remaining 23 hours let it run through shafts and tunnels upon turbines? This would bring the cost of a look at the falls down to about $7—the price of three theatre tickets instead of the price of six suits of clothes.

But, some one may urge, who would come hundreds of miles, just for one hour's pleasure? Do this thing that you propose and the audience will stay away. Hardly, for the gorge itself is a royal vision at all times, and then if there be those who insist upon a continuous performance of the falls themselves, why not give it to them in a grand amphitheatre where a screen 100 ft. long would picture the "roaring waters" in all save the roar.

Jesting aside, it is a very high price, a price unnecessarily high, that Canada and America are paying for trips to Niagara Falls. Let us have a little real social engineering brought to bear on this esthetic-economic problem and we shall, without doubt, find a way to utilize nearly all the power now wasted at Niagara, yet not deprive mankind of its heritage of beauty and grandure.

## EDITORIAL PARAGRAPHS.

Precision and absurdity become inextricably mixed in many hydraulic computations. When inherent uncertainties range around 5 to 15 per cent in determining consumption, stream flow, run-off, reservoir capacity, etc., it is pure absurdity to use many significant figures in writing results. Precision is satisfied sufficiently when tens of thousands of gallons or second feet are made the limit for consideration.

America is the land of the pressure tunnel for water supply. A rough count schedules over 30 tunnels that come within this classification, and none but tunnels for potable water supply were counted. For water power and irrigation there must be a great many more. Incidentally the Catskill Aqueduct has eight pressure tunnels, none less than 11 ft. in diameter, aggregating 35½ miles in length.

Wood stave pipe laid in Butte, Mont., 24 years ago, is still in good condition. Yet when that pipe was laid there were few engineers who would have predicted a total life of 24 years for it. What its full life will be no one can more than guess.

## WATER WORKS AND HYDRAULICS MONTHLY ISSUE AN EXCELLENT IDEA.

To the Editors: In regard to your proposed scheme by which you publish a special issue devoted to water works and hydraulics every month, I wish to say that I think that this is an excellent idea. It has been necessary for us in the past—for those of us who attempted to keep up-to-date on water works problems—to burden our files with an enormous amount of engineering material which did not concern us in any degree.

Yours very truly,
Jack J. Hinman, Jr.,
Sr. Water Bacteriologist and Chemist,
State Board of Health.
Iowa City, Ia., July 19, 1916.

## A FOUR-TRACK PERIODICAL.

To the Editors: Please enter my subscription for your four-track periodical. For ten years I have found Engineering and Contracting, with all the variations in its visible forms, the only sine qua non in my battle with and against humanity on the one hand and things elemental on the other. While I was satisfied with your arrangement heretofore of matter presented, I am a little bit dubious as to the satisfactory operation of the four-track. For my own part, I want to operate on all four, and I don't see why any consistent subscriber would care to limit himself. I have never been a producer of engineering literature, cannot offer anything like constructive criticism to an editor, but to me, a consumer, monthly has ever been too few and far between, and if you do not carry a better lazy man's index in the future than you have in the past I can see that I shall have to become less mnemonic in my reference system.

Be that as it may, you get my $3. I am glad you are not retailing this new system at $1 per C. without rebates. And while chatting I might express my gratitude at a continuation of the same size of page. I prefer the old smaller page of a couple of years ago, but am glad (once more) that the new system will not require more width and breadth to shelve. I don't suppose any great percentage of your subscribers carry Engineering and Contracting folded once in a coat pocket to take quarter or half hour snatches at as I do, so thought I would take the above shot from the library position.

In conclusion I wish to commend the good work you are doing both for the status and the calling of engineers, and wish for Engineering and Contracting a continued full measure of the success which it deserves.

Yours truly,
C. P. Keyser.
1147 E. Yamhill St., Portland, Ore.

## "WATERWORKS HANDBOOK."*

One author collects from engineering experience all knowledge available, transmutes it in the laboratory of his brain and produces a volume of general principles, laws and rules for performing an engineering task. Another author selects from recorded engineering experience the items of knowledge and opinion regarded by him as most worthy and arranges them in logical order and systematic form to make a book complete in its discussion of a selected subject. A book of the first kind was reviewed two weeks ago in our Bridges and Structures Monthly Issue. Here we review a volume of the second kind and one that is truly notable in its class on its subject.

Waterworks engineering has perhaps, next to structural engineering, been the subject of more books than any other branch of the civil engineer's work. It has been the last branch of his work selected by the civil engineer as an author to be discussed in a comprehensive treatise as of present date. Irrigation engineering has its modern treatise; sewerage practice, bridge engineering, reinforced concrete design and construction has each within a year or two had its complete treatise. The waterworks book before us is labled a handbook, but in volume of matter and thoroughness of treatment it is equivalent to any of these named treatises. The book has 801 text pages, 38 chapters, 311 numbered tables and 411 numbered illustrations. By means of a small type and carefully condensed drawings the volume of text is much larger, than in most books, per page occupied. Judging by the eye its 800 pages are equivalent to at least a thousand pages of the ordinary book type. Its index of 44 page long columns is one of the most complete published in a book on engineering. Of the authors, Mr. Flinn is deputy chief engineer of the Board of Water Supply of New York, and Mr. Bogert is an assistant engineer of the same organization. Mr. Weston is a consulting sanitary engineer of high standing and long experience. We have named these gentlemen authors; they name themselves modestly, compilers, and their book, a "usable compilation." We would add that the book is a notably useful and complete compilation.

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*Waterworks Handbook.—By Alfred D. Flinn, Robert Spurr Weston and Clinton L. Bogert. New York, McGraw-Hill Book Co. Flexible cloth; 6x9 in.; pp. 824; illustrated; $6.

Scheduling the subjects treated in a book of such size and scope is a task that cannot be accomplished in limited space. There are five "parts" to the book: (I) Scurces of Water Supply; (II) Collection of Water; (III) Transportation and Delivery of Water; (IV) Distribution of Water; (V) Character and Treatment of Water. The chapters carry the reader from the falling rain to the testing of the filter effluent. Of these chapters some are of more notable length and quality. The chapters on dams, on wells, on plate metal pipes, on pumps and pumping stations are particularly noteworthy. Another feature of the book is the thoroughness with which it covers the use of cement and concrete in waterworks construction. A separate chapter is devoted to hydraulic computations and there is another on capacity and conversion tables. These additional chapters are noted since they characterize this book as primarily a reference book. The user is assumed to have familiarity with mathematics, hydraulics, the natural sciences and with ordinary waterworks construction and maintenance problems. The book is not a text book and herein is its virtue as compared with most waterworks books.

## PUMPING WATER FROM WELLS ON THE SALT RIVER PROJECT.*

There are in operation on the Salt River Project, Arizona, nine pumping plants which pump water from an underground supply.

The character of the formation of soil is as follows: For the first 150 ft. the material consists of alternating layers of adobe, clay and dry sand, varying in thickness from 4 to 40 ft.; for the next 122 ft., the material consists of first-class water gravel and bowlders; the last 3 ft. to a total depth of 275 ft. consist of gravel and bowlders with a trace of mud.

The diameter of the casings used is 16 in. and the depth of water from the surface is about 36 ft. The casings are perforated for a depth of 150 to 272 ft. with four holes ½ in. wide by 10 in. long, spaced 30 in. apart vertically. The effective area of all of these perforations in any one casing is 6.8 sq. ft.

At each plant three drilled wells from 200 to 300 ft. in depth, located in a straight line, spaced 30 ft. apart, are connected by tunnel to the pump located in a caisson which is from 38 to 53 ft. in depth. Provision is made for sand pumping any single well without interfering with the operation of the others.

These plants have all been in operation for over three years and no trouble has been experienced from pipes getting clogged with sand. A very small amount of sand is pumped immediately after starting up a plant, but after running a few minutes the water is perfectly clear.

## LEONARD METCALF, PRESIDENT AMERICAN WATER WORKS ASSOCIATION.

Leonard Metcalf, Consulting Engineer of the firm of Metcalf & Eddy, Boston, Mass., was elected President of the American Water Works Association at its convention held in New York City in May, 1916. In 1915 Mr. Metcalf served as president of the New England Water Works Association. He is a graduate of the Massachusetts Institute of Technology and is 46 years old. His experience in water works and sewerage engineering has been extended, the firm of which he is a member having designed and constructed and served in consulting capacity on many of the most important undertakings of the last decade. As engineers for the Boston Finance Commission this firm made a study of municipal services which stands unique in excellence among investigations of this character. In recent years Mr. Metcalf has devoted much attention to water works valuation and has become a leading authority on the subject.

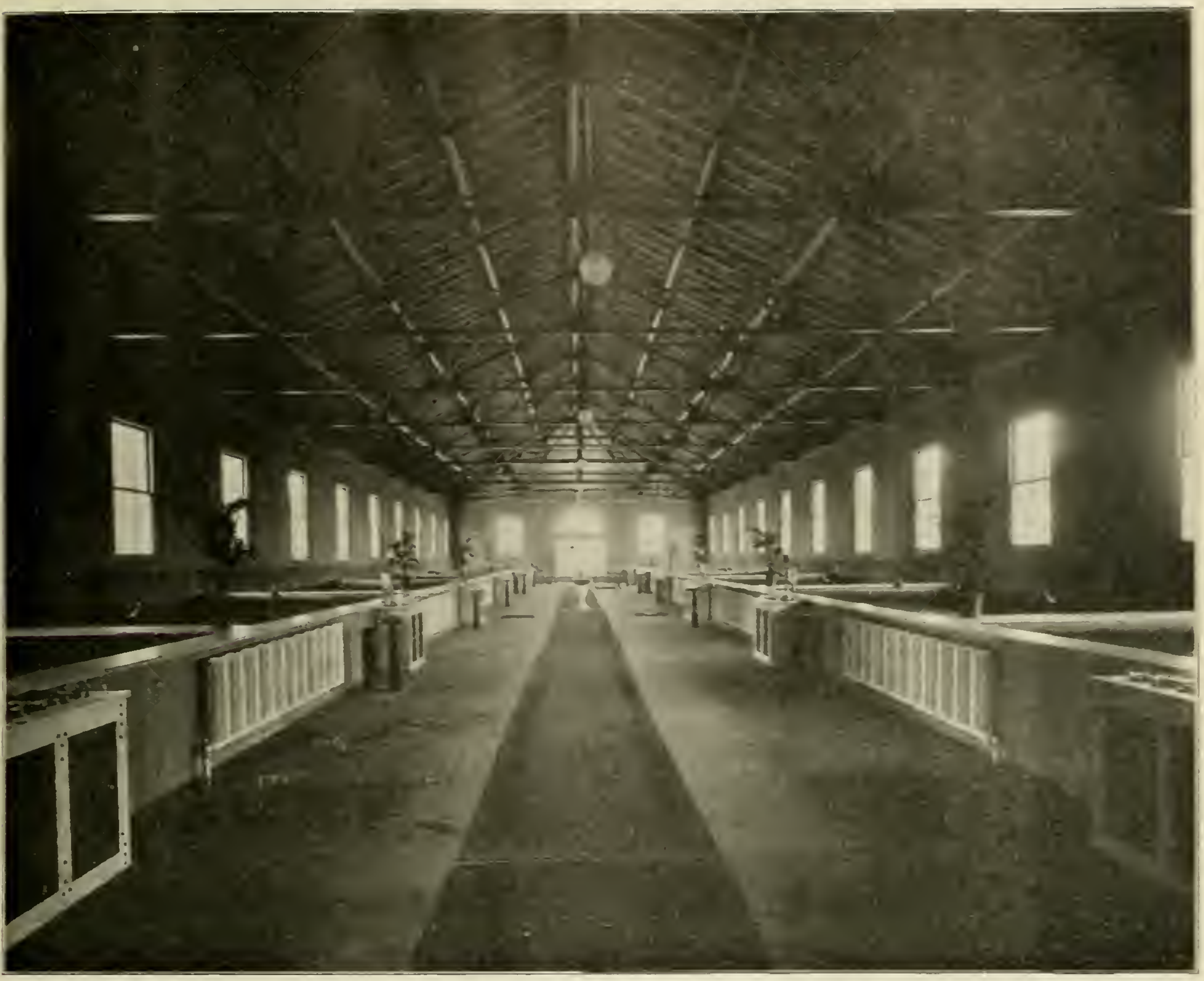
## COST OF OPERATING A FORD CAR FOR THREE YEARS.

During the years 1913 to 1915 inclusive a Ford touring car (20 h.p.) of 1912 model was used on the Grand Valley project of the U. S. Reclamation Service. It traveled 14,200 miles at the following average operating cost per mile:

| | Cts. |
|---|---|
| Gasoline | 1.21 |
| Oil | 0.25 |
| Tires | 1.63 |
| Repairs ⅛ | 4.82 |
| Total | 7.91 |

The depreciation suffered during this 3-yr. period is estimated to be about $445 or 3.1 ct. per mile in addition to the above. Interest on the investment would be about 0.7 ct. per mile. Garage expense was nearly 0.8 ct. per mile. This makes a grand total cost of 15.6 ct. per mile for an average of 4,730 miles per year.

It will be noted that repairs and depreciation were both very high, which indicates that the road conditions were severe. In 1915 the machine traveled about 17 miles on a gallon of gasoline and 230 miles on a gallon of oil.



Interior View of Filter Operating Gallery of the Erie, Pa., Water Works.

## VALUE OF DECORATION OF FILTER OPERATING GALLERIES.

The operating gallery of a modern water filtration plant is essentially utilitarian in purpose. To serve this purpose it needs to be kept clean and sanitary and the construction needs to be of a character that will facilitate sanitation. Embellishment is not a requirement for successful and sanitary operation. There is, however, a value in embellishment. The operating gallery of a filter plant and the laboratory of a filter plant are practically the only working parts of the plant to which the consumer has access. They are the only visual exhibits of the mechanism of filtration, a mechanism of which the average consumer has little understanding. Any favorable impression that the visitor may receive of the efficiency of this mechanism must come through the eye. In this manner embellishment has value. As an example the operating gallery of the filter plant at Erie, Pa., is illustrated. No engineer need be told that the carpeting, the potted plants, the fountain, the nickel and enamel operating tables, the silvered radiators, etc., are unnecessary to perfect purification. Were none of these embellishments present the water delivered at the consumer's taps would be just as pure and sparkling. Would, however, the consumer visitor, not seeing these embellishments and the immaculate cleanliness everywhere prevailing be so thoroughly convinced of the perfection of his tap water? He most certainly would not be and herein is the value of the embellishments seen in the view shown. Mr. Edward W. Humphreys is superintendent of water works of Erie, Pa.

## SAND BLASTING AND PAINTING STEEL WATER TANK.

The tank forms an extra high service reservoir and is 100 ft. in diameter and 44¼ ft. high and held 2,500,000 gal. It is part of the system of the Metropolitan Water District of Massachusetts, and had been in service about two months when the painting was begun. The contractors for the work were the W. L. Waples Co., Boston, Mass. The plant used consisted at first of a 20-h.p., gasoline engine driven air compressor, a compressed air reservoir, two lines of air hose and two nozzles. Sand blasting was stopped in the latter part of the afternoon of each day and the cleaned surfaces were painted before rusting commenced. The force employed included 1 foreman, 2 painters, who also did sand blasting, and 1 helper. This force could sand blast and paint an area of about 330 sq. ft. per day. Later, in order to increase the rate of progress, a second compressor, operated by an automobile engine, was installed on April 19. The entire inside and outside surface of the tank, having an area of 35,650 sq. ft., was sand blasted and painted. Work was begun on March 30 and was completed June 14, with the exception of the third coat on the outside, which has been deferred until after the masonry tower which encloses the tank is completed. All painting materials were furnished by the department, but were mixed by the contractor under the direction of the engineer. For the inside of the tank National Lead Co.'s red lead in oil paste, litharge and Spencer-Kellogg & Son's boiled linseed oil were used; the first coat natural color, the second and third coats tinted with lamp black in oil. For the outside of the tank red lead paste, raw linseed oil and drier were used for the first coat, and for the second coat white lead, raw linseed oil, turpentine and drier tinted with lamp black were used. One gallon of red lead paint was sufficient to cover 700 sq. ft. of surface with one coat. The sub-contractor's price for sand blasting and painting the tank was $1,600.

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# COST OF STRUCTURES OF THE SECOND UNIT OF THE DODSON NORTH CANAL, MILK RIVER IRRIGATION PROJECT, MALTA, MONT.

Contributed by A. E. Bechtel, Salt Lake City, Utah.

## I.

There were a number of different classes of structures: spillways, concrete box culverts, vitrified and cast iron pipe culverts, wooden bridges, turnouts, checks, flume, etc. All of the materials for the work, excepting sand and gravel, were furnished by the government at the railroad station most convenient to the work, the contractor being held responsible for them after delivery at these points.

The sand and gravel was obtained in the coolies along the work, hauled to the structures and there screened by hand before being used. The quality was good but the supply was not very large, it being necessary sometimes to cover considerable area to get the amount required. Boulders for the paving were picked up along the foot hills near by.

**Equipment.**—The equipment used on the structures consisted of a Milwaukee 10 cu. ft. steam mixer, a Van Dusen 6 cu. ft. gasoline mixer, each with elevating loaders, together with such other equipment as is common to this class of work. The concrete was mixed by machine except on the small structures where, on account of the cost of moving the mixer, it was found to be more economical to mix by hand.

The reinforcing steel was cut and bent in the yard (see Fig. 1), from cutting lists furnished by the engineers, tagged and hauled to the structures as it was needed.

The lumber for the bridges and bulkheads was hauled from the cars to the yard, and afterwards distributed to the work as needed, while the lumber for the checks, turnouts and flume was cut up in the yard from diagrams with a power saw, then hauled and erected on the work.

**Description.**—The reinforcing steel was square twisted bars, cut and bent to conform to the structures, generally placed about 2 in. from the surface of the concrete, about 80 lb. being used per cubic yard of concrete. Structural steel was used in the checks and spillways.

Rubble concrete and dry paving were placed on the embankment slopes, on the beds and banks of canals, and on other water courses of the structures.

The method of construction of rubble concrete paving was as follows: After the sub-grade was prepared, 4 in. of concrete was spread, into which boulders were imbedded with close joints, by hand. Over this a mortar consisting of 3 parts of sand and 1 part of cement was brushed to fill the voids. The paving when complete, was about 9 in. thick (see Fig. 2).

The dry paving was similar to rubble except that sand and gravel was placed in a layer 6 in. thick in place of concrete and larger stones imbeded in it, then sand and gravel brushed over the top, making the paving 12 in. thick.

The method used in designating the location of the structures was to number them in relation to their location on the canals or laterals. For example structure 545 would be located at station 545 on the main canal, 1210-2 would signify station 2 on lateral 1210 which branched off from the main canal at station 1210.

**Spillways.**—At the points where the canal crossed water courses, where the amount of water during the flood season was too great to be taken care of by placing culverts under the canal, spillways were constructed. These were of two general types. In a spillway of the first type, water entered at the upper bank of the canal and passed out at the lower bank without materially increasing the water level of the canal. The second type may be designated as the automatic type. With the automatic spillway it was possible to drain the canal, or to keep the water at a uniform depth by means of gates which were controlled by water pressure at a fixed level.

Spillways of the first type were not complex in their construction, being made for the most part of dry and rubble concrete paving on the sides, slopes, and bottom of the canal. At the lower side or outlet, was placed a structural steel check, with flash boards to control the height of the water. The second type (see Fig. 3) were similar to the first in construction with the exception of the spillway proper, which was of concrete with from two to eight openings built across the outlet, equipped with steel gates, which were controlled automatically by the water pressure in the canal, thus keeping the canal at a uniform level.

The automatic spillways were constructed as follows: The excavation was first done in the rough with teams and scrapers, after which the canal bottom, and slope were finished by hand to lines. While the paving gang were placing the paving the carpenters erected the forms Then after the concrete was poured and the forms stripped, the back filling was done, and the paving completed near the concrete, and on the bottom and slopes of the outlet.

Before any work was done on the automatics, two sets of forms were made. Each of the structures was a little different, having a different number of openings, but as the openings were the same size the forms were made in units so that it was necessary only to use the number of units rquired. The sections were put together with pins, and they were very easily collapsed. The piers were 1 ft. thick with 6 in. slabs.

**Box Culverts.**—Five box culverts (see Figs. 4 and 5) were built where the main canal passed under the Great Northern Ry. These were a double rectangular box with 12 in. walls and wing walls on either end, 9 in. thick and a batter of 1 to 12. The canal was paved at either end of 10 ft. beyond the culvert box. The sizes of the boxes were from 3 ft. by 3 ft. to 4 ft. by 4 ft. 6 in.

There was also a conduit to carry lateral 121 under a water way. This was 2 ft. 6 in. by 3 ft. and 200 ft. long with walls and floor 6 in. thick and cover, and wing walls 9 in. thick.

The excavation under the railway after a temporary trestle had been put in by the railway company was done by first removing all the earth with teams and scrapers as near the railway as possible, then making a passage under the track with picks and shovels of room for one horse after which a one-horse slip was employed, until sufficient room was had to use two horses. The government paid for a slope of 1 to 1.

After the grading was all finished the steel for the floor was placed and the concrete placed in the floor, setting the vertical reinforcing in the concrete. The forms were now erected and the concreting finished.

The forms for the boxes were made in 8 ft. sections of 2x4 in. laging on 2x4 in. uprights and cross braced with a 2x6 in. on top and a 2x4 in. on the bottom all spaced 4 ft. on center, and fastened together with ½ in. pins.

**Pipe Culverts.**—The pipe culverts were of cast iron and vitrified clay with 9 in. concrete headwalls, the inlets and outlets being paved with rubble concrete (see Figs. 6 and 7). The cast iron pipe, 18 in. and 24 in. in diameter, was placed where laterals passed under the Great Northern R. R. The excavation was made in open cut after the railroad company had put in temporary pile crossings. There was one exception to this, it being tunneled.

The vitrified pipe, in sizes from 12 in. to 30 in. in diameter, was laid where small water courses crossed the canals, the excavation being made in open cut before the canal was constructed. The elevation of the top of the pipe was about 2 ft. below the grade of the canal.

**Bridges.**—Bridges were built at all places where the canals and ditches crossed public roads, there being about

TABLE 1.—COST OF REINFORCED CONCRETE STRUCTURES.

| | Av. Mile Haul | | | | | | | Labor Cost | | | | | | | | | | | Material. | Overhead Charge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure. | Cement. | Sand-Gravel. | Water. | Supplies. | Quantity. Cu. yd. | Method of Mixing. | Proportion. | Forem'n. Unit. | Sand-Gravel. Unit. | Screening. Unit | Bldg. Forms. Unit. | Erect. Forms. Unit. | Remov. Forms. Unit. | Haul. Water. Unit. | Handl'g Cement. Unit. | Mix. Place. Unit. | Finishing. Unit. | Total Field Cost. Unit. | Form Labor, Nails, Etc. Unit. | Gen'l Supervision Unit. | Equipment. Unit. | Cont. Exp. Unit. | Cont'r's Total Cost. Unit. |
| Spillway | 2.2 | 3.0 | .4 | 2.2 | 128 | M-1 | 136 | $0.42 | $1.31 | $0.39 | .... | $0.64 | $0.10 | $0.44 | $0.31 | $1.25 | .... | $ 7.86 | $0.48 | $1.14 | $0.79 | $2.01 | $12.28 |
| Spillway | 2.0 | 2.5 | 1.2 | 2.0 | 69 | M-1 | 136 | .64 | 1.33 | .30 | .... | 1.03 | .08 | .45 | .44 | 6.94 | .... | 11.21 | .49 | 2.41 | 2.39 | 1.22 | 16.80 |
| Spillway | 2.0 | 1.0 | 1.0 | 2.0 | 63 | M-1 | 136 | .34 | 1.31 | .35 | .... | 1.41 | .14 | .44 | .38 | 2.86 | .... | 7.26 | .48 | 1.06 | .72 | 1.83 | 11.35 |
| Spillway | 2.5 | .7 | .6 | .6 | 93 | H | 136 | .49 | 1.42 | .73 | .... | .64 | ... | .27 | .17 | 1.64 | .... | 5.45 | 1.00 | .51 | .72 | .72 | 8.30 |
| Spillway | 1.3 | 2.0 | .5 | .5 | 53 | H | 136 | .46 | 1.42 | .62 | .... | 1.94 | ... | .10 | .33 | 1.96 | .... | 6.82 | 1.02 | .65 | .91 | .91 | 8.58 |
| Total and average | 2.0 | 1.8 | .6 | 1.5 | 406 | .. | 136 | .46 | 1.38 | .48 | .... | 1.00 | .07 | .36 | .31 | 3.60 | .... | 7.62 | .68 | 1.58 | 1.05 | 1.11 | 11.92 |
| Box culvert | 2.0 | 2.5 | 1.0 | 2.0 | 847 | M-2 | 135 | .30 | 1.42 | .34 | $0.05 | 1.23 | .17 | .26 | .01 | .98 | $0.29 | 5.10 | 1.02 | .48 | .67 | .67 | 7.90 |
| Box culvert | .7 | 1.0 | .5 | 1.0 | 895 | M-2 | 135 | .26 | 1.42 | .13 | .06 | 1.22 | .09 | .29 | .29 | 1.22 | .12 | 5.10 | 1.02 | .51 | .72 | .72 | 8.35 |
| Box culvert | 2.0 | 1.5 | .7 | 2.0 | 868 | M-2 | 135 | .33 | 1.42 | .23 | .19 | .87 | .21 | .29 | .19 | 1.20 | .08 | 5.09 | 1.02 | .48 | .67 | .67 | 7.93 |
| Box culvert | .5 | .7 | .7 | 5.0 | 819 | M-2 | 135 | .49 | 1.42 | .23 | .13 | .76 | .17 | .37 | .20 | .83 | .04 | 4.71 | 1.02 | .46 | .65 | .65 | 7.37 |
| Box culvert | 1.0 | 1.0 | .3 | 4.5 | 711 | M-2 | 135 | .60 | 1.42 | .23 | .29 | .88 | .16 | .16 | .21 | .90 | .25 | .... | 1.02 | .47 | .79 | .79 | 7.09 |
| Total and average | 1.2 | 1.3 | .7 | 2.9 | 4,140 | M-2 | 135 | .38 | 1.42 | .29 | .14 | 1.01 | .15 | .28 | .19 | 1.04 | .15 | 5.05 | 1.02 | .48 | .70 | .70 | 7.85 |
| Box culvert | 2.5 | 1.2 | 2.0 | 2.0 | 606 | H | 134 | 1.08 | 1.42 | .42 | .74 | 1.72 | .19 | .11 | .07 | 1.39 | .06 | 7.20 | 1.02 | .69 | .96 | .96 | 10.83 |
| Lip spillway | 1.0 | 1.0 | 1.0 | 1.0 | 19 | M-1 | 136 | .26 | 1.31 | .43 | ... | .... | ... | .45 | ... | .36 | ... | 2.51 | .48 | .20 | .23 | .59 | 4.02 |
| Automatic spillway | 2.0 | 2.0 | 1.0 | 2 0 | 285 | M-2 | 135 | .57 | 1.31 | .43 | 1.19 | 2.65 | .34 | .41 | .32 | 1.17 | ... | 11.42 | .48 | 1.76 | 2.91 | 1.15 | 17.72 |
| Automatic spillway | 2.0 | 2.0 | 1.0 | 2.0 | 481 | M-2 | 135 | .47 | 1.34 | .46 | .71 | 2.39 | .24 | .32 | .23 | 4.49 | .11 | 10.79 | .92 | 2.01 | 2.08 | 1.32 | 17.15 |
| Automatic spillway | 1.0 | 1.3 | .5 | 1.0 | 354 | M-1 | 135 | .60 | 1.46 | .31 | 1.72 | 1.76 | .37 | .11 | .26 | 2.49 | .19 | 9.46 | 1.00 | 1.11 | 1.00 | 1.54 | 14.20 |
| Automatic spillway | 2.0 | 2.0 | .5 | 2.0 | 425 | M-1 | 135 | .37 | 1.42 | .39 | 1.53 | 1.78 | .21 | .15 | .11 | 1.76 | .33 | 8.14 | 1.02 | .74 | 1.04 | 1.04 | 11.83 |
| Automatic spillway | 2.5 | .7 | .5 | 4.0 | 314 | M-1 | 135 | .55 | 1.12 | .52 | 1.53 | 1.18 | .31 | .21 | .27 | 1.54 | .20 | 7.68 | 1.02 | 1.06 | 1.06 | 1.06 | 11.84 |
| Automatic spillway | 2.5 | 1.0 | 0.0 | 5.0 | 302 | H | 135 | 1.16 | 1.42 | .37 | 1.53 | 1.09 | .22 | ... | .42 | 1.53 | .09 | 8.59 | 1.02 | .93 | 1.29 | 1.29 | 13.10 |
| Total automatic spillway | 2 0 | 1.5 | .6 | 2.5 | 2,191 | .. | 135 | .55 | 1 44 | .41 | 1.33 | 1.96 | .28 | .27 | .25 | 2.73 | .17 | 9.35 | .91 | 1.29 | 1.56 | 1.24 | 14.35 |
| Sluice and check | 1.0 | 2.5 | .5 | 1.0 | 86 | H | 135 | 1.74 | 1.42 | .50 | .... | 2.67 | .35 | .24 | .08 | 1.48 | .36 | 8.90 | 1.02 | .84 | 1.18 | 1.18 | 13.15 |
| Flume piers and head walls | 2.5 | 2.5 | .5 | 2.5 | 377 | M-1 | 135 | .13 | 1.42 | .35 | .... | 1.09 | .18 | .28 | .26 | 2.43 | .02 | 6.30 | 1.02 | .58 | .81 | .81 | 9.34 |
| Pipe head walls | .1 | 1.0 | .5 | .1 | 56 | M-1 | 135 | .71 | 1.12 | .25 | .... | 1.52 | .07 | .24 | .71 | 1 01 | .07 | 6.00 | 1.02 | .57 | .79 | .79 | 9.15 |
| Pipe head walls | 4.0 | 2.0 | .5 | 4.0 | 57 | H | 135 | .21 | 1.42 | .21 | .... | 1.52 | .13 | .12 | .12 | 2.61 | .23 | 6.63 | 1.02 | .62 | .88 | .88 | 10.03 |
| Pipe head walls | 3.0 | 1 0 | .5 | 7 0 | 57 | H | 135 | .21 | 1.12 | .31 | .... | .77 | .30 | .18 | .18 | 2.46 | .10 | 5.93 | 1.02 | .57 | .79 | .79 | 9.10 |
| Pipe head walls | 2 0 | 2.0 | 2.0 | 2.0 | 11 | H | 135 | 1.22 | 1.12 | .45 | .... | .98 | ... | .62 | .31 | 2.36 | ... | 7.36 | 1.02 | .70 | .98 | .98 | 11.04 |
| Pipe head walls | 1.0 | 1.5 | .5 | 1.0 | 69 | H | 135 | .61 | 1.30 | .35 | .... | 2.76 | ... | .11 | .33 | 3.39 | ... | 9.18 | .48 | 1.20 | .90 | 2.31 | 11.07 |
| Pipe head walls | 2.0 | 1.0 | 1.0 | 2.0 | 75 | H | 135 | .63 | 1.31 | .53 | .... | 1.60 | ... | .33 | .35 | 3.55 | ... | 8.33 | 1.00 | .59 | .56 | 1.03 | 11.51 |
| Pipe head walls | 2.5 | 3.0 | .5 | 2.5 | 18 | H | 135 | ... | 1.12 | .64 | .... | 1.54 | ... | .27 | .23 | 2.40 | ... | 6.50 | 1.02 | .62 | .85 | .85 | 9.84 |
| Pipe head walls | 2 0 | 0.7 | .2 | 2.5 | 55 | H | 135 | .92 | 1.12 | .26 | .... | .92 | .07 | .36 | ... | 1.26 | ... | 5.21 | 1.02 | .50 | .70 | .70 | 8.13 |
| Total | 2 1 | 1.9 | .7 | 2.6 | 458 | .. | 135 | .55 | 1.30 | .38 | .... | 1.50 | .07 | .31 | .28 | 2.45 | .05 | 7.12 | .92 | .68 | .79 | 1.08 | 10.52 |
| Turnout | 2 5 | 1.3 | 2.0 | 2.5 | 148 | H | 124 | 1.01 | 1.12 | .39 | .... | 1.08 | .22 | .26 | .27 | 1 48 | .07 | 6.20 | 1 02 | .58 | .81 | .81 | 9.42 |
| Turnout | 1 5 | 1.3 | .8 | 5.0 | 110 | H | 124 | .68 | 1.42 | .30 | .... | 1.61 | .21 | .12 | .20 | 1.89 | .11 | 6.60 | 1.02 | .61 | .84 | .84 | 9.91 |
| Total | 2 0 | 1.3 | 1 4 | 3.7 | 258 | H | 121 | .87 | 1.42 | .35 | .... | 1.30 | .23 | .20 | .24 | 1.65 | .10 | 6.35 | 1.02 | .59 | .83 | .83 | 9.60 |
| Pressure pipe | 1 0 | 1 2 | 1 0 | 5.0 | 2,357 | M 2 | 124 | .59 | 1.42 | .43 | .70 | 1.07 | .33 | .20 | .22 | 1.16 | .31 | 6.43 | 1.02 | .61 | .86 | .86 | 9.70 |
| Head walls | 1.0 | 2.5 | .7 | 1.0 | 162 | H | 135 | 1.39 | 1.42 | .32 | .... | 1.52 | .17 | .08 | .32 | 1.68 | .05 | 8.00 | 1.02 | .76 | 1.07 | 1.02 | 11.92 |
| Checks | 1 5 | 2 0 | .7 | 1 0 | 101 | H | 135 | ... | 1.53 | .35 | .... | 2.06 | .23 | .19 | .25 | 2.07 | .30 | 8.25 | 1.02 | .79 | 1.08 | 1.08 | 12.22 |
| Bridge piers | 3 0 | 2.5 | 1.5 | 2.0 | 280 | H | 136 | ... | 2.73 | .66 | .... | 1.12 | .19 | .54 | .61 | 5 18 | ... | 11.33 | 1.00 | 1.33 | 1.23 | 2.06 | 12 00 |
| Structures | 3 0 | 2 5 | 1.0 | 3.0 | 12 | H | 136 | ... | 1.50 | ... | .... | 1.25 | ... | .15 | .15 | 1.55 | ... | 4.60 | 1.00 | .43 | .61 | .61 | 7.25 |
| Total concrete | 2 0 | 1.5 | .7 | 3.0 | 11,583 | .. | ... | .52 | 1.45 | .38 | .49 | 1.30 | .23 | .27 | .23 | 1.76 | .16 | 6.79 | .97 | .74 | .95 | .96 | 10.41 |

30 of them. Across the waste water ditches one span only, resting on an 8x12 in. mudsill, was necessary, but for the canals two and three spans were built on concrete pedestals with 6x6 in. posts, 3x12 in. stringers and floor. The bridges averaged from 5,000 to 6,000 ft. to the bridge. The bridges were built in two different counties. In one county only a 6x6 guard was used on the side while in the other a railing was used (see Fig. 8).

**Hess Flume.**—One Hess steel flume 3 ft. 9 in. diameter and 515 ft. long was constructed over a coulie or ravine (see Fig. 9) on a frame structure. The posts were 6x8 in. cross braced with 2x6 in. A 3x12 in. rib was gained on top on which the flume rested. The posts rested on concrete pedestals, anchored with bolts set in the concrete. The lumber was cut up in the yard, hauled to the site of the work, bolted together and erected into place. Concrete wing walls were built and the sides and bottom of the canal paved at either end of the flume after which the flume sections were joined and laid. Four men could lay about 100 ft. per day.

**Outlets.**—At four places where waste water ditches discharge into the river (see Fig. 10) corrugated iron pipe in sizes from 30 in. to 48 in. was laid. After the excavation was made, ten 12 in. by 20 ft. piles were driven with a 600 lb. hammer to refusal at the point nearest the river. The pipe was laid beginning at the piles. At the inlet of the pipe a bulkhead was constructed of three thicknesses of 2x8 in. lumber. The pipe was then backfilled to a depth of about 10 ft.

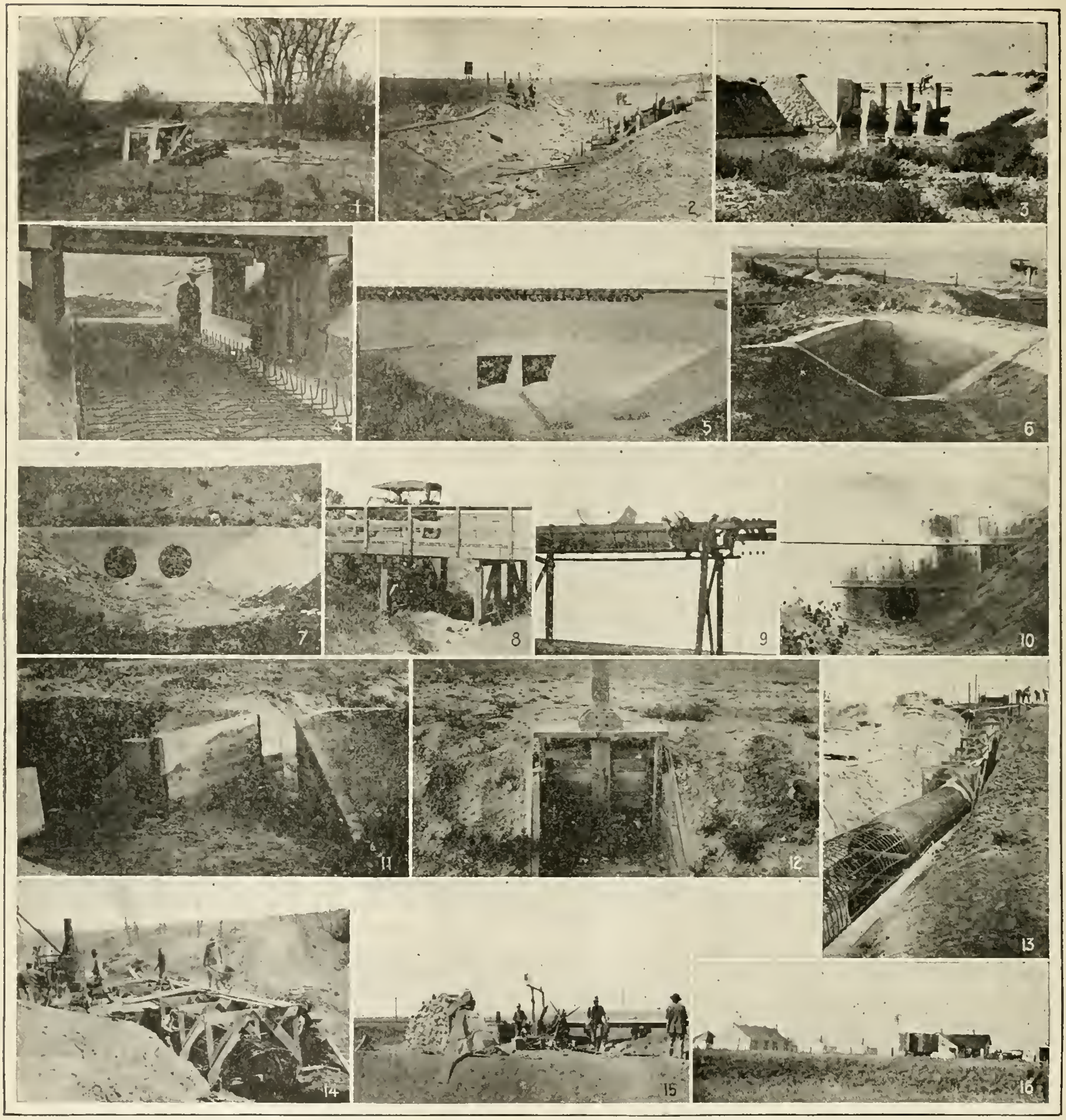
**Turnouts and Checks.**—There were four concrete checks (see picture 8-1; 8-2; 9-2) and two concrete turnouts (see Fig. 11) with 6 in. walls, paved at the outlet. The rest of the checks and turnouts were of wood (see Fig. 12). The wooden turnouts and checks were cut up in the yard, hauled out in bundles and erected on the work. They contained from 300 to 500 ft. B. M. to the structure.

**Pressure Pipe.**—The largest structure on the work was a 5 ft. 4 in. circular concrete conduit (see Fig. 13) 400 ft. long, involving 2,341 cu. yd. excavation, 500 cu. yd. back fill, 24,171 lb. steel, 235 cu. yd. concrete and 55 yd. paving. The pipe had walls 6 in. thick with wing walls at either end 9 in. on top with a batter of 1 in 12. At the entrance was a spillway emptying into Exeter Creek.

The excavation for the pipe was made on a 1 to 1 slope to 6 in. below the center line, leaving a 12 in. bench. Below this point the earth was used for the outside form of the concrete. The greater part of the excavation was done with 5 ft. Fresnoes, the finishing being done with drag scrapers and shovels.

The reinforcing steel for around the pipe was bent in circles on a table, and tied. It was then erected in the ditch and the horizontals tied on after which it was blocked to bring it to the center of the finished concrete.

The concrete was then placed in the bottom and spread with a templet, covering a little more than one-sixth of the circumfer-



CANAL STRUCTURES, SECOND UNIT, DODSON CANAL MILK RIVER PROJECT, U. S. RECLAMATION SERVICE.

(1) Steel Cutting and Bending Yard. (2) Dry Rubble Paving. (3) Automatic Spillway Structure. (4) Floor Reinforcement, Box Culvert. (5) Outlet of Box Culvert. (6) Pipe Culvert Inlet. (7) Pipe Culvert Outlet. (8) Highway Bridge. (9) Laying Hess Flume. (10) Waste Water Ditch Outlet. (11) Check and Spillway. (12) Farm Turnout. (13) Pressure Pipe Construction. (14) Concreting Pressure Pipe. (15) Mixing Concrete for Rubble Paving. (16) Construction Camp.

ence of the pipe. Upon this bottom the inside forms were erected and braced to the reinforcement.

The forms were built in one-sixth of a circle, five segments being used, leaving out the lower one-sixth. One section on each side extended from the invert up to the horizontal diameter of the conduit. The second section reached from this diameter to the fifth or key sections at the top. Each of the sections consisted of 2x10 in. ribs cut to the proper curve and lagged with 2x4 in. lumber. The ribs of the sections were spared 4 ft. on centers and were braced with 2x4 in. cross braces on top and bottom and 2x6 in. in the center. These were held together with ½ in. pins.

The outside forms were also made in sections and held in place with bents resting on planks laid to grade on the 12 in. base referred to in excavation. The posts of these bents were 4x6 in. timbers connected across the top by a 2x10 in. plank set in gains and bolted to them. Each post also was attached to the cross piece by a knee brace belted in place. These were placed on 8 ft. centers and held in position horizontally with cross bracing of 1x4's.

The forms for the interior of the conduit were made in 8 ft. lengths and the design was such that after removing the inside bracing the top or key section dropped down allowing the whole form to collapse. As the forms were erected, a 2x4 in. track was layed on the center brace, and a home-made car placed on it. As the forms were taken down they were placed on this car and pulled ahead with a rope to the uncompleted section, to be used again. The car was then pulled back by a rope from the other end, ready for reloading.

One hundred lineal feet of forms were made and after the pipe was completed, they were taken apart and used in making sectional forms for box culverts.

TABLE II.—COST OF REINFORCING AND STRUCTURAL STEEL.

| Structures. | Mile Haul. | Qpantity, Pounds. | Labor Cost | | | | | Overhead Charge | | | Cont'r's Total Cost. Unit. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hauling. Unit. | Cutting. Unit. | Bending. Unit. | Placing. Unit. | Field. Cost. Unit. | General Supervision. Unit. | Equipment. Unit. | Cont. Exp. Unit. | |
| Spillway | 2.5 | 444 | ....... | ....... | ....... | $0.0210 | $0.0210 | $0.0040 | $0.0030 | $0.0060 | $0.0033 |
| Spillway | 2.0 | 308 | ....... | ....... | ....... | .0330 | .0330 | .0070 | .0040 | .0080 | .0520 |
| Spillway | .5 | 284 | ....... | ....... | ....... | .0310 | .0310 | .0060 | .0030 | .0080 | .0480 |
| Spillway | 2.5 | 299 | $0.0031 | $0.0015 | $0.0018 | .0216 | .0280 | .0027 | .0033 | .0033 | .0390 |
| Spillway | 1.5 | 165 | .0033 | .0015 | .0018 | .0170 | .0237 | .0018 | .0027 | .0027 | .0310 |
| Automatic spillway | 2.0 | 1,539 | ..... | ..... | ..... | .0335 | .0335 | .0070 | .0035 | .0090 | .0531 |
| Automatic spillway | 1.0 | 2,384 | ..... | ..... | ..... | .0188 | .0188 | .0036 | .0018 | .0046 | .0288 |
| Automatic spillway | 1.0 | 2,034 | .0059 | .0015 | .0018 | .0140 | .0143 | .0013 | .0018 | .0018 | .0192 |
| Automatic spillway | 2.0 | 2,486 | .0005 | .0015 | .0018 | .0095 | .0133 | .0013 | .0018 | .0018 | .0169 |
| Automatic spillway | 3.0 | 2,120 | .0012 | .0015 | .0018 | .0073 | .0120 | .0011 | .0016 | .0016 | .0164 |
| Automatic spillway | 2.0 | 1,454 | .0044 | .0015 | .0018 | .0030 | .0132 | .0010 | .0014 | .0014 | .0145 |
| Sulice and check | 1.0 | 320 | .0031 | .0015 | .0018 | .0047 | .0325 | .0031 | .0033 | .0033 | .0422 |
| Flume head walls | 2.5 | 997 | .0006 | .0015 | .0018 | .0042 | .0081 | .0008 | .0008 | .0011 | .0111 |
| Pipe head walls | 5. | 236 | .0020 | .0015 | .0012 | .0051 | .0100 | .0008 | .0064 | .0064 | .0123 |
| Pipe head walls | 3. | 148 | .0040 | .0015 | .0018 | .0116 | .0150 | .0013 | .0018 | .0018 | .0206 |
| Pipe head walls | 2.5 | 148 | .0040 | .0015 | .0018 | .0055 | .0320 | .0011 | .0012 | .0012 | .0158 |
| Pipe head walls | 2.0 | 222 | .0020 | .0015 | .0018 | .0045 | .0099 | .0009 | .0015 | .0015 | .0138 |
| Pipe head walls | 1.0 | 1,096 | .0019 | .0014 | .0019 | .0027 | .0078 | .0007 | .0008 | .0008 | .0123 |
| Concrete turnouts | 1.5 | 2,513 | .0008 | .0013 | .0012 | .0026 | .0067 | .0007 | .0008 | .0008 | .0092 |
| Concrete checks | 1.0 | 581 | .0009 | .0012 | .0010 | .0039 | .0070 | .0007 | .0009 | .0009 | .0094 |
| V. P. head walls | .5 | 260 | ..... | ..... | ..... | .0072 | .0072 | .0015 | .0008 | .0019 | .0114 |
| V. P. head walls | 2.5 | 214 | ..... | ..... | ..... | .0084 | .0084 | .0019 | .0014 | .0019 | .0132 |
| V. P. head walls | 1.5 | 245 | .0008 | .0015 | .0020 | .0049 | .0094 | .0008 | .0013 | .0013 | .0130 |
| V. P. head walls | 2.5 | 240 | .0010 | .0015 | .0018 | .0100 | .0145 | .0013 | .0017 | .0017 | .0190 |
| Concrete box culvert | 2.0 | 9,055 | .0010 | .0015 | .0018 | .0034 | .0077 | .0007 | .0010 | .0010 | .0105 |
| Concrete box culvert | 1.0 | 9,795 | .0004 | .0015 | .0018 | .0040 | .0077 | .0007 | .0010 | .0010 | .0104 |
| Concrete box culvert | 2.0 | 9,040 | .0006 | .0015 | .0018 | .0045 | .0078 | .0008 | .0015 | .0015 | .0116 |
| Concrete box culvert | 1.0 | 9,682 | .0012 | .0015 | .0018 | .0029 | .0075 | .0007 | .0010 | .0010 | .0100 |
| Concrete box culvert | 1.5 | 7,346 | .0016 | .0015 | .0018 | .0025 | .0073 | .0007 | .0010 | .0010 | .0101 |
| Concrete box conduit | 2.0 | 6,845 | .0004 | .0015 | .0018 | .0034 | .0070 | .0006 | .0009 | .0009 | .0097 |
| Pressure pipe | .5 | 24,171 | .0007 | .0015 | .0018 | .0048 | .0087 | .0008 | .0012 | .0012 | .0118 |
| Total reinf. | ... | 96,471 | .0009 | .0015 | .0018 | .0055 | .0095 | .0013 | .0012 | .0014 | .0131 |
| Total struc. steel | 2.0 | 4,726 | .0030 | ..... | ..... | .0140 | .0133 | .0013 | .0015 | .0015 | .0170 |

TABLE III.—COST OF PIPE CULVERTS AND FLUMES.

| Structures. | Lin. ft. | Size, in. | Labor cost | | | Lead and tar joint. Unit. | Overhead charge. | | | Contr.'s total cost. Unit. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hauling. Unit. | Laying. Unit. | Field cost. Unit. | | General supervision. Unit. | Equipment. Unit. | Cont. exp. Unit. | |
| 24-in. cast iron Ry. culvert | 72 | 24 | $1.40 | $3.90 | $5.30 | $1.80 | $0.50 | $0.70 | $0.70 | $9.00 |
| 18-in. cast iron Ry. culvert | 96 | 18 | 2.70 | 3.80 | 6.40 | 1.50 | 0.52 | 0.85 | 0.85 | 10.30 |
| 18-in. cast iron Ry. culvert | 36 | 18 | 1.00 | 1.66 | 2.66 | 1.20 | 0.25 | 0.35 | 0.35 | 4.73 |
| 18-in. cast iron Ry. culvert | 36 | 18 | 1.00 | 1.98 | 2.98 | 1.20 | 0.30 | 0.39 | 0.39 | 5.19 |
| 18-in. cast iron Ry. culvert | 36 | 18 | 1.00 | 2.82 | 3.83 | 1.20 | 0.36 | 0.51 | 0.51 | 6.35 |
| Total 18-in. pipe | 204 | 18 | 1.70 | 2.98 | 4.70 | 1.29 | 0.46 | 0.62 | 0.62 | 7.25 |
| 30-in. vitrified pipe culvert | 172 | 30 | .... | .... | 5.80 | .... | 0.12 | 0.06 | 1.60 | 9.10 |
| 18-in. vitrified pipe culvert | 72 | 18 | 0.57 | 1.04 | 1.60 | .... | 0.16 | 0.21 | 0.21 | 2.32 |
| 24-in. vitrified pipe culvert | 113 | 24 | 0.35 | 1.60 | 1.95 | .... | 0.19 | 0.26 | 0.26 | 2.66 |
| 24-in. vitrified pipe culvert | 153 | 24 | 1.13 | 2.73 | 3.83 | .... | 0.44 | 0.18 | 0.50 | 4.97 |
| Total 24-in. pipe | 266 | .. | 0.79 | 2.26 | 3.06 | .... | 0.33 | 0.22 | 0.40 | 4.02 |
| Vitrified pipe culvert under canal | 80 | 12 | 0.66 | 0.47 | 1.14 | .... | 0.11 | 0.15 | 0.15 | 1.56 |
| | 44 | 12 | 1.44 | 1.84 | 3.35 | .... | 0.32 | 0.44 | 0.44 | 4.56 |
| Total 12-in. pipe | 124 | .. | 0.96 | 0.96 | 1.92 | .... | 0.19 | 0.26 | 0.26 | 2.63 |
| 36-in. corrugated pipe outlet | 80 | 36 | 0.63 | 0.90 | 1.49 | 0.63 | 0.32 | 0.16 | 0.41 | 3.03 |
| 36-in corrugated pipe | 80 | 36 | 1.26 | 1.43 | 2.16 | 0.63 | 0.23 | 0.10 | 0.25 | 3.75 |
| 48-in. corrugated pipe | 100 | 48 | 1.10 | 1.22 | 2.32 | 0.50 | 0.30 | 0.44 | 0.44 | 4.00 |
| 30-in. corrugated pipe | 80 | 30 | 1.50 | 1.30 | 1.80 | 0.63 | 0.26 | 0.37 | 0.37 | 4.43 |
| Hess St. flume | 515 | 39 | 0.10 | 9.91 | 1.00 | .... | 0.10 | 0.12 | 0.12 | 1.34 |

TABLE IV.—COST OF DRY PAVING CANAL STRUCTURES.

| Structure. | Cu. yd. dry paving. | Mile haul. | Labor Cost | | | Overhead Charge | | | Contractor's total cost. Unit. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel & rock. Unit. | Placing. Unit. | Total field cost. Unit. | General supervision. Unit. | Equipment. Unit. | Cont. Exp. Unit. | |
| Spillway | 39.1 | 2.0 | $1.31 | $1.98 | $3.30 | $0.65 | $0.35 | $0.88 | $5.17 |
| Spillway | 30.0 | 1.5 | 1.31 | 1.28 | 2.59 | .54 | .27 | .69 | 4.10 |
| Automatic spillway | 16.4 | 1.5 | 1.31 | 1.31 | 2.76 | .53 | .30 | .70 | 4.28 |
| Automatic spillway | 34.7 | 1.5 | 1.31 | 1.19 | 2.47 | .52 | .27 | .67 | 3.95 |
| Automatic spillway | 47.3 | 1.0 | 1.31 | 1.16 | 2.47 | .51 | .26 | .66 | 3.91 |
| Automatic spillway | 17.7 | 1.0 | 1.31 | .96 | 2.27 | .24 | .48 | .61 | 3.61 |
| Automatic spillway | 20.0 | 1.5 | 1.37 | .70 | 2.12 | .20 | .27 | .27 | 2.81 |
| Automatic spillway | 17.8 | 1.0 | 1.26 | .52 | 1.76 | .17 | .23 | .23 | 2.39 |
| Spillway | 29.5 | 1.0 | 1.46 | .85 | 2.31 | .22 | .31 | .31 | 3.16 |
| Spillway | 23.2 | 1.5 | 1.53 | .90 | 2.44 | .23 | .33 | .33 | 3.34 |
| Pressure pipe | 26.0 | 1.0 | 1.46 | .82 | 2.27 | .22 | .30 | .30 | 3.10 |
| Automatic spillway | 34 3 | 1.0 | 1.52 | .27 | 1.80 | .17 | .24 | .24 | 2.46 |
| Conduit | 32.8 | 1.0 | 1.29 | .45 | 1.96 | .15 | .23 | .23 | 2.36 |
| Flume | 3.7 | 1.5 | 1.42 | 1.83 | 3.25 | .31 | .39 | .39 | 4.31 |
| Total paving | 372.5 | 1.5 | 1.37 | 1.01 | 2.38 | .35 | .29 | .49 | 3.51 |

The concrete was mixed in a 10 cu. ft. Milwaukee mixer (see Fig. 14) and wheeled in barrows or spouted through a chute directly into the forms. The concrete was kept as nearly equal as possible on both sides of the pipe to keep the pressure equal on the forms. The work was completed with a small gang placing about 35 ft. per day.

## Labor.

Labor in eastern Montana consists mostly of what are known as dry-landers. That country still has much government land that has never been taken up, and being one of the last parts of the United States to be settled, there is quite a rush to that country. This class of labor, picked from most every walk of life, is not experienced, and therefore, not efficient or satisfactory.

The wages paid were from $2.75 to $3.75 per 8 hr. day, averaging about $3, carpenters and steel men $4. Teams, without drivers, were paid $30 per month and feed.

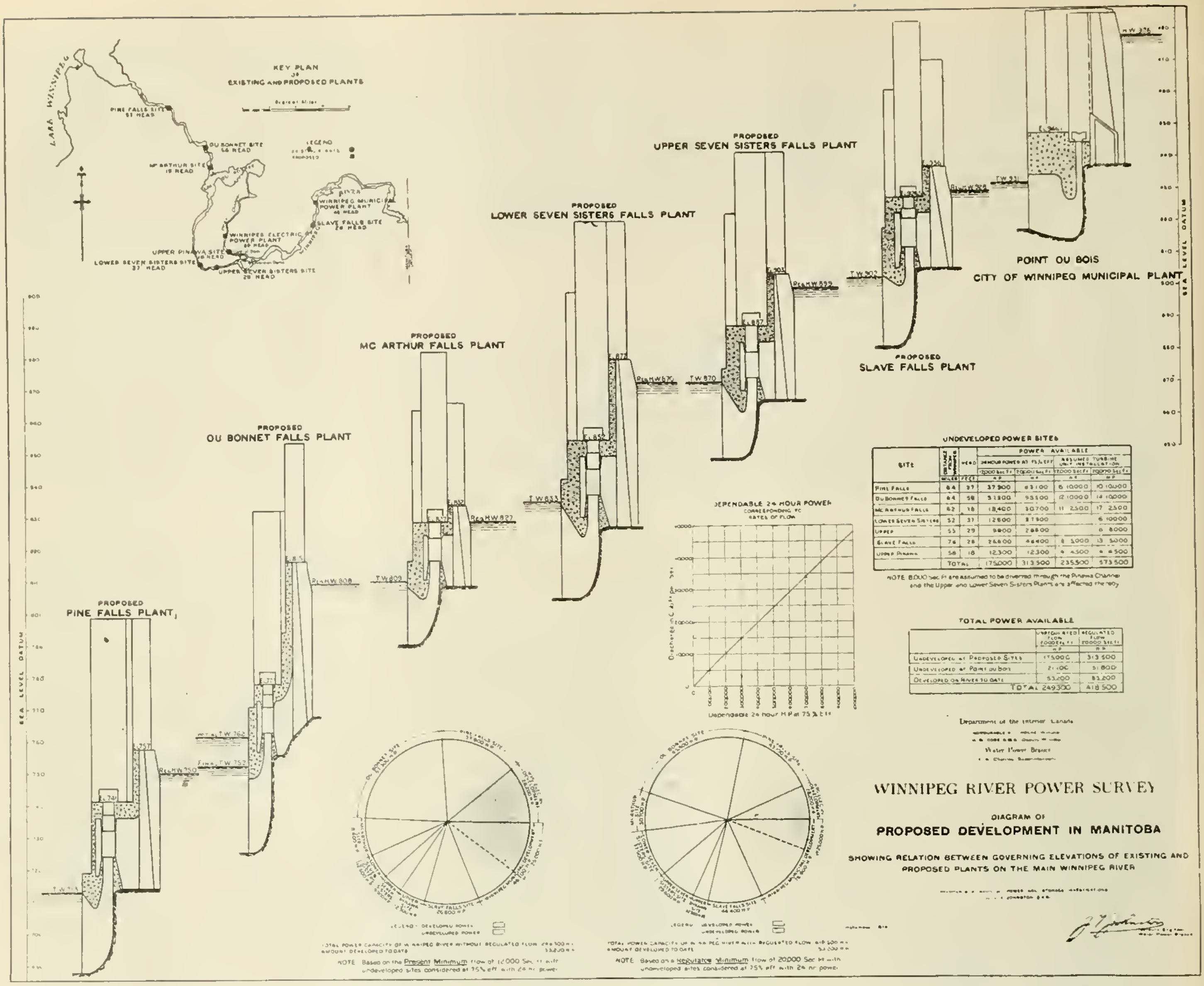
The climate of Montana is good for construction work, during eight months of the year. That is from April 1 to Dec. 1, but for concrete work from May 1 to Nov. 1 is better, as any earlier or later requires protection of the work, even in October the weather gets severe at times.

Referring to the cost for the work done during November and December of 1913, structures 545 and 743 illustrates the effect of the weather on the work. A part of this high cost might be caused by the contractor's unfamiliarity with that class of work, as well as a poor organization.

All of the inspectors on the work were graduate engineers, and although they required the work done as nearly as possible to conform to plans and specifications, they were very reasonable and much superior to inspectors on most public work.

The contract extended over a distance of 18 miles and required seven camps, ranging in size from 15 to 60 men, and from 4 to 80 head of stock.

Tents with Tiger bunks including board were furnished the men at 90 ct. per day. The camps were located in general so as to make two miles the maximum distance to go to work, but this was not always possible on account of difficulty in securing suitable camping sites.


KEY PLAN OF EXISTING AND PROPOSED PLANTS
LAKE WINNIPEG
PINE FALLS SITE 37 HEAD
DU BONNET SITE 56 HEAD
McARTHUR SITE 18 HEAD
WINNIPEG MUNICIPAL POWER PLANT 46 HEAD
SLAVE FALLS SITE 26 HEAD
WINNIPEG ELECTRIC POWER PLANT
UPPER PINAWA SITE
LOWER SEVEN SISTERS SITE 37 HEAD
UPPER SEVEN SISTERS SITE 29 HEAD
LEGEND
PROPOSED PINE FALLS PLANT
PROPOSED DU BONNET FALLS PLANT
PROPOSED MC ARTHUR FALLS PLANT
PROPOSED LOWER SEVEN SISTERS FALLS PLANT
PROPOSED UPPER SEVEN SISTERS FALLS PLANT
PROPOSED SLAVE FALLS PLANT
POINT DU BOIS
CITY OF WINNIPEG MUNICIPAL PLANT
SEA LEVEL DATUM
DEPENDABLE 24 HOUR POWER
UNDEVELOPED POWER SITES
SITE | DISTANCE FROM WINNIPEG | HEAD | POWER AVAILABLE: 24 HOUR POWER AT 75% EFF. 12000 Sec Ft / 20000 Sec Ft | ASSUMED TURBINE UNIT INSTALLATION 12000 Sec Ft / 20000 Sec Ft
MILES | FEET | H.P. | H.P. | H.P. | H.P.
Pine Falls | 64 | 37 | 37900 | 63100 | 6 10000 | 10 10000
Du Bonnet Falls | 64 | 56 | 51200 | 95500 | 12 10000 | 14 10000
McArthur Falls | 62 | 18 | 18,400 | 30700 | 11 2500 | 17 2500
Lower Seven Sisters | 52 | 37 | 12800 | 27900 | | 6 10000
Upper | 55 | 29 | 9800 | 28800 | | 6 8000
Slave Falls | 76 | 26 | 26600 | 46400 | 8 5000 | 13 5000
Upper Pinawa | 58 | 16 | 12300 | 12300 | 4 4500 | 4 4500
TOTAL | 175000 | 313500 | 235500 | 373500
NOTE 8,000 Sec Ft are assumed to be diverted through the Pinawa Channel and the Upper and Lower Seven Sisters Plants are affected thereby
TOTAL POWER AVAILABLE
| UNREGULATED FLOW 12000 Sec Ft | REGULATED FLOW 20000 Sec Ft
| H.P. | H.P.
Undeveloped at Proposed Sites | 175000 | 313500
Undeveloped at Point du Bois | 21100 | 51800
Developed on River to date | 53200 | 53200
TOTAL 249300 | 418500
Department of the Interior Canada
Water Power Branch
WINNIPEG RIVER POWER SURVEY
DIAGRAM OF
PROPOSED DEVELOPMENT IN MANITOBA
SHOWING RELATION BETWEEN GOVERNING ELEVATIONS OF EXISTING AND PROPOSED PLANTS ON THE MAIN WINNIPEG RIVER

Scheme of Water Power Development on the Winnipeg River, Manitoba.

## WATER POWER POSSIBILITIES OF THE WINNIPEG RIVER IN MANITOBA.

A recent report issued by the Water Power Branch of the Department of the Interior, Canada, shows that there will eventually be as much if not more power available from the Winnipeg River than is now being developed at Niagara. Writing of this development, Mr. J. B. Challies, Superintendent, Dominion Water Power Branch, says:

The investigations of which this report is the result were carried on by the Department of the Interior primarily for administrative purposes. The work has covered a period of five years, and at a total cost of approximately $70,000. The best possible expert and experienced engineering advice was obtained at the inception, and throughout the investigations. The results, therefore, must be taken as the considered opinion of the best engineering and administrative advice.

Not only has the government in its endeavor to administer these water powers in the best possible manner carried out these investigations, but a sum of over $104,000 has been spent in re-purchasing properties along the Winnipeg River from private parties, which were required for power purposes, and which might some time in the near future be held for an exorbitant sum, and thereby add unnecessarily to the capital cost of the power developments.

The water power regulations under which these water powers are administered are considered to be fair and reasonable to the owners, the developers and the users of the water powers, that is to say, to the Crown, the corporation and the people.

These investigations show that at nine distinct power sites, by means of storage easily and cheaply accomplished at the Lake of the Woods, at Lac Seul and other lakes in the province of Ontario, it is possible and economically feasible to develop over 418,000 continuous 24-hour horsepower, all within 75 miles of the city of Winnipeg, and within feasible transmission distance of all commercial centers of the present settled portions of the province.

Of the nine possible power sites on the Winnipeg River, there are three now under development, representing a total power capacity of 200,000 24-hour horsepower. One site is completely developed by the Winnipeg Electric Railway Co. on the Pinawa channel, and produces about 28,000 hp. Another site at Point du Bois Falls, developed by the city of Winnipeg, produces at the present time about 25,000 continuous horsepower, but it is capable of extensions to a maximum of 77,000 24-hour horsepower. Development at the third power site at Great or du Bonnet Falls, having a maximum possible development of 95,000 24-hour horsepower, is about to be commenced by the Winnipeg River Power Co.

There is, therefore, at the present time about 53,000 continuous horsepower produced, and transmitted for use in and around the city of Winnipeg, which can, with the two present plants, be increased to 200,000 24-hour horsepower.

The six remaining power sites are under the control of the Dominion Government, and can furnish a further amount of 24-hour power to a maximum extent of 218,000 hp.

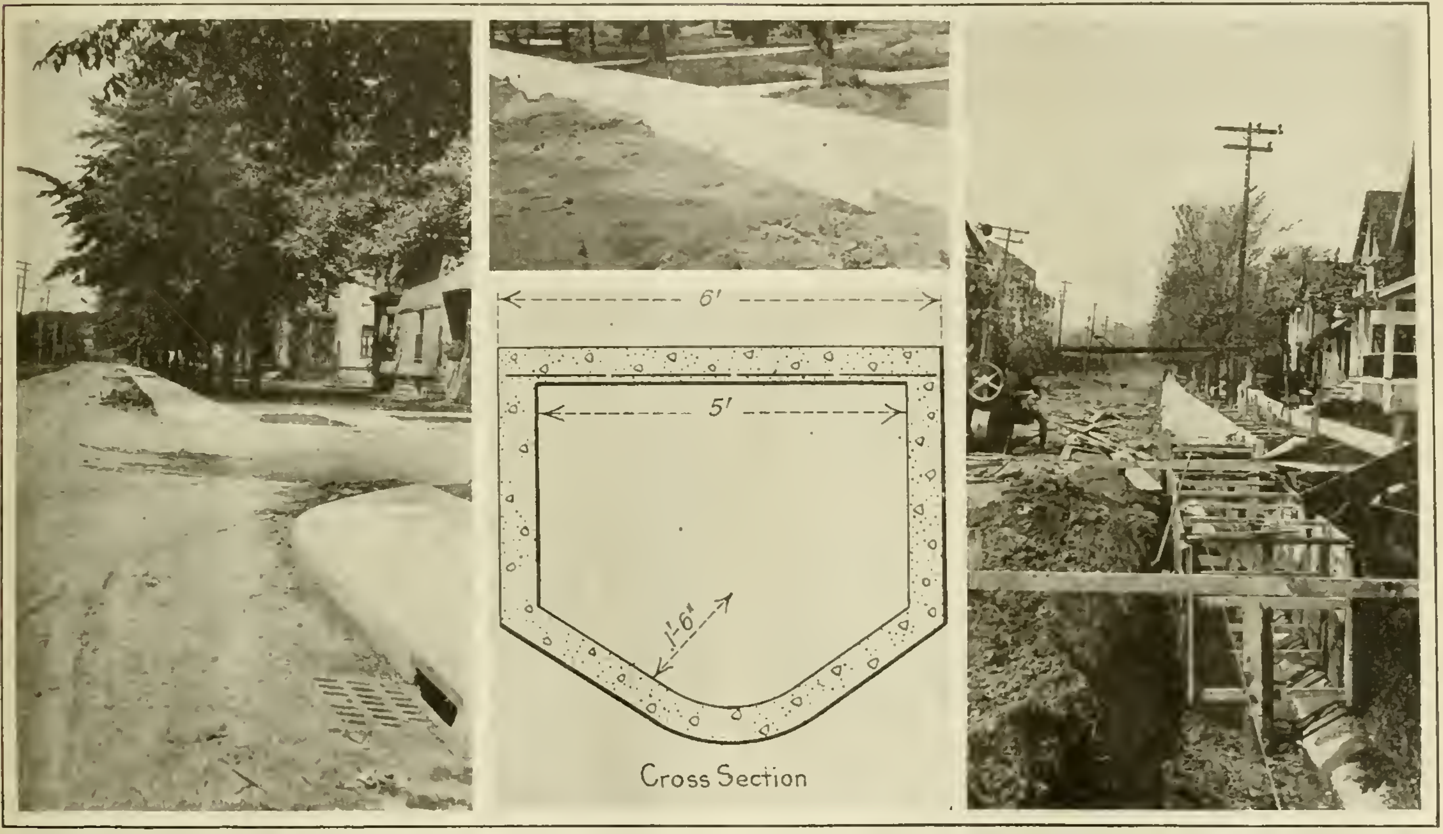
In addition, there are several important power sites on the Winnipeg and English rivers within the province of Ontario, which are within easy transmission distance of Winnipeg.

The accompanying diagram presents in condensed form the main features of the development planned. The engineers by whom the investigations were conducted were: John R. Freeman, New York; J. B. McRae, Ottawa, Ont., and J. T. Johnston, chief hydraulic engineer, Water Power Branch. The report was prepared by Mr. Johnston.

## COMBINED SIDEWALK CURB AND STORM WATER SEWER, ANN ARBOR, MICH.

A novel combination of structures is shown by the accompanying illustrations furnished by Manley Osgood, city engineer of Ann Arbor, Mich. A storm water sewer of the section shown was built under the sidewalk line in such manner that its top slab would serve as sidewalk and its edge as curb. The structural details of the section are given by the line drawing. The photographic views show the structure under construction, the arrangement at entrances to alleys or private drives and the construction at intersecting streets. As the grade of sidewalk, owing to these and other conditions, did not conform to the regular 3 per cent grade of the sewer invert the variation was taken care of by varying the height of the sewer sidewalls. The unit and total costs of the structure were as follows:

| | |
|---|---|
| 1,640 cu. yd. excavation, at .65 | $1,066.00 |
| 9,646.4 sq. ft. reinforcing, at .02 | 192.93 |
| 540.6 cu. yd. of concrete, at 8.45 | 4,568.07 |
| 110.5 lin. ft. of 12-in. pipe, at .33 | 36.47 |
| 3 tees 12 in., at 1.00 | 3.00 |
| 5 elbows, 12 in., at 1.00 | 5.00 |
| 7 iron box inlets, at 12.00 | 84.00 |
| 8 cast iron covers, at 5.50 | 44.00 |
| Minor extras | 51.63 |
| Total | $6,051.10 |



Structural Features of Combined Sidewalk, Storm Sewer and Curb, Ann Arbor, Mich.

## ELIMINATING A MOSQUITO BREEDING POOL BY BLASTING.

The following item is extracted from the Year Book for 1916 of the Commissioners of the Borough of Haddonfield, N. J.

"The residents of West Haddonfield were for years pestered and tormented by mosquitoes which it was learned, upon investigation, were propagated in stagnant pools between the railroad and Haddon Ave. It was found practically impossible to drain these to the street gutters hence another method had to be employed and it was decided to sink the water into the ground. Under the supervision of L. Z. Lawrence a heavy charge of dynamite was sunk and discharged about 20 ft. under the surface. This caused the pools to disappear in short order and no water has accumulated at this point up to the end of the year."

## A SMALL SEWAGE SPRINKLING FILTER WITH UNIQUE FEATURES.

Contributed by R. C. Hardman, Consulting Engineer, Cheyenne Bldg., Colorado Springs, Colo.

A small sprinkling filter designed on a very simple basis so as to require as little attention as possible, has just been installed to handle the sewage from a pleasure park near Colorado Springs, Colo. The filter, which has an area of but 0.206 of an acre, takes care of the sewage from Stratton Park and that from about 200 small summer cottages in the immediate vicinity of the park. The sewage from the entire district is collected in the park, where it is treated in a 1-story sludge tank. The tank formerly discharged its effluent into Cheyenne Creek, about 200 ft. away, in close proximity to a convalescent sanatorium just outside the park boundary. At times the effluent from the tank gave off so offensive an odor that numerous complaints were made. No trouble was had when the creek channel was running full, as the discharge was under the surface of the water. However, in the summer when the discharge of sewage is at the maximum, the flow of the creek is often at its minimum, sometimes a mere trickle.

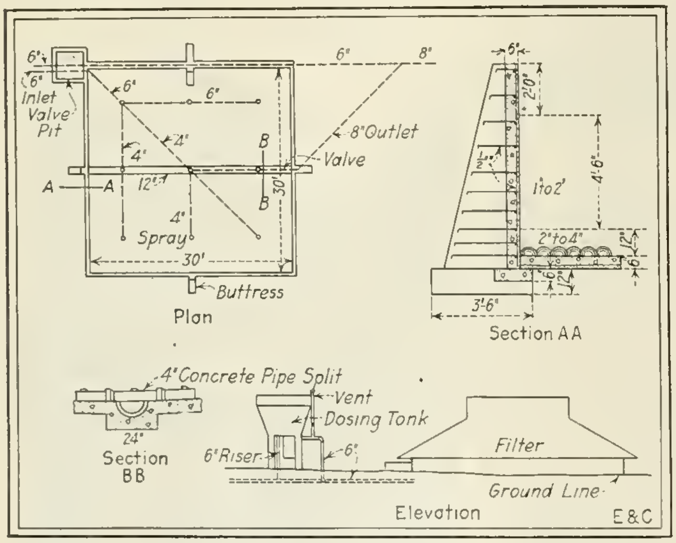
From investigations made it is believed that the objectionable odors were due in great measure to the poor design of the tank, which bears the name of a plumbing goods supply house. The tank is designed properly to care adequately for its maximum capacity, which is about 40,000 gal., but is not suited to the conditions under which it must operate. The conditions are peculiar. In the summer thousands of people visit the park daily, it being located at the entrance of both North and South

Cheyenne Canons, which are famed for their tourist attracting qualities. In addition to the daily crowd of visitors, the cottages are filled, so that the average daily flow is easily from 40,000 to 50,000 gal., with possibly a greater amount on Sundays and holidays. In the winter the park visitors are practically nil and the permanent population using the sewers is not in excess of 100 at any time. Thus the sewage flow is perhaps not much over 5,000 gal. per day.

With the variation in flow from 5,000 to 50,000 gal. per day, it will be readily seen that a single compartment tank of 40,000-gal. capacity can not be efficient. In the summer it is working at very near its designed capacity, in the winter the sewage must of necessity remain in the tank for from eight to ten days. It is extremely probable that putrefaction takes place instead of the action desired. It was recommended that the tank be redesigned and divided into compartments so that the rate of flow through it could be regulated to suit the sewage flow in the various seasons.

The officials in charge, however, to obviate any possible future complaints, decided to carry the effluent downstream some 4,000 ft. and further treat it by filtration. As the filter will probably never receive much attention, it was made on a nearly "fool-proof" plan.

The filter is contained in a reinforced concrete tank as shown in the accompanying plan, partly in excavation. The distributing system is of cast iron and enters the tank at one corner, covering the tank in herringbone fashion. It is supported upon the coarse filter material near the bottom of the tank. The risers are of 3-in. cast iron and are fitted with square-spray Taylor nozzles spaced on 10-ft. centers. All distributing pipes are drained in the directions shown on the plan and into the discharge pipe.



Sewage Sprinkling Filter Plant, Colorado Springs, Colo.

The collecting system consists of a semi-circular channel 12 in. in diameter, running down the center of the tank. The floor of the tank slopes toward the channel with a fall of 6 in. in 15 ft., and is covered with a 4-in. split concrete pipe laid with staggered joints, which act as lateral collectors.

The filter bed consists of 1 ft. of 2-in. to 4-in. broken stone and gravel and 4.5 ft. of broken phonolite ranging from 1 in. to 2 in. in size.

The entire tank is covered with a frame building with large louvres in each gable to allow a free circulation of air and to prevent clogging by heavy snow falls.

The dosing apparatus consists of an elevated tank situated a short distance from the filter. It is of the tapered type supported by concrete columns, and has a capacity of about 700 gal. To secure the necessary head for the operation of the dosing tank, a section of the sewer line above the tank is used as a pressure line, which is believed to be a unique feature. This was rendered feasible without special preparation as the entire line was constructed of concrete sewer pipe, lengths of which, selected at random, withstood hydraulic pressures from 92 to 97 lb. per square inch, with no seepage until 60 lb. was reached.

The dosing tank is located directly over the sewer line, from which the sewage rises through a tee up. An automatic siphon discharges it into the distributing system of the filter. To provide for the small amount of solid matter which will not rise into the siphon chamber the sewer line extends past the dosing tank and through one wall of the filter, forming a by-pass. This line being controlled by a valve allows of the discharge of the solid matter directly into the stream whenever necessary. The solid matter will be practically negligible, as the small amount which succeeds in passing the sludge tank is thoroughly broken up in passing through the 4,000 ft. of line, which has a fall of some 200 ft.

The plant is designed to allow a second unit to be built alongside should circumstances demand it.

## HOUSE CONNECTIONS AS FACTOR IN INFILTRATION.

Contributed by W. W. Dixon of The Atlas Company, Lincoln, N. J.

The infiltration into a sewer system is usually recorded and spoken of as gallons per sewer mile per day, while some authorities state it should be recorded as gallons per inch of exposed joint. By the latter method it gives the writer opportunity to sustain his claim that with the rigid specifications now in vogue drawn by competent engineers the bulk of ground water that has to be pumped and treated does not come alone from the joints of the sewer line proper, designed by and constructed under the supervision of the Engineer, but in a greater proportion from the house connections as made by various contractors and not subjected to the same rigid inspection. The sewer proper on completion, before house connections are made, shows a certain leakage, more or less (?), than calculated in original planning that from the arguments of some engineers will decrease after the sewer has been in use for a year or more, by the solids in the sewage filling the inside joint at invert and the back fill becoming more compact. But this theory is not proven, as—take the case of Sewer at Stamford, Conn., designed by the late Col. Geo. E. Waring, Jr., where the infiltration of 1.16 miles of sewer was measured when there were only 215 house connections and flow was 49,340 gal. per mile per day. The sewer flow was again measured in a drier season of the year when there were 530 house connections, and the flow measured 94,170 gal. per mile per day or nearly 100 per cent increase in flow, or an average of 160 gal. per day for each house connection which does not sound reasonable.

Therefore if the leakage in the sewer is from joints the following table will give approximate figures of number of inches of exposed joints on line 1,000 ft. of 8-in. Depp & Wide Socket Pipe, 3 ft. lengths, and the comparative inches of exposed joint in house connections.

1,000 ft. 8-in. D. & W. pipe, 3 ft. length exposed joints in inches, 11,800 in.

House connections every 50 ft., 4-in. tile, 2 ft. lengths, average length, 50 ft., 18,060 in.

House connections every 25 ft., 4-in. tile, 2 ft. lengths, average length, 50 ft., 36,120 in.

Again the street sewer is protected from precipitation by macadam, concrete, brick, and bituminous pavements, while the greater length of house connections are in pervious soil that readily absorbs the precipitation, allowing it to penetrate to the unnaturally formed water course, the sewer trench.

Therefore, is it not important that more attention should be paid to this department of Sewer to enable the engineering department to have the sewers they designed line up to the original expectations?

The writer several years ago produced a compound that will not show deterioration from the action of acids, alkalies, domestic sewage, or salt or fresh water. The compound allows for flexibility of joint and positively fills the joint and hermetically seals it.

## SPACING DIAGRAM FOR HOOP REINFORCING FOR REINFORCED CONCRETE STANDPIPES.

Contributed by Frank H. Carter, Designing Engineers, Cliftondale, Mass.

In the design of reinforced concrete standpipes, the writer has found that the problem of spacing the roundabout reinforcing rods vertically in the walls of the structure involves an almost endless amount of arithmetical labor. To obviate this work, a spacing diagram (Fig. 1) was evolved during the design of the last standpipe of reinforced concrete undertaken by the writer, with satisfactory results. The height of the structure was 35 ft., and the thickness of the side wall was 12 in. at the top and 18 in. at the base, being plumb on the inside only, the taper being all on the outer face. The reinforcing rods were laid in pairs and were supported on iron frames as shown in the detail drawing, Fig. 2. Twelve sets of frames were used in a circumference of 125 ft. Provision was made for horizontal joints, every 30 in. though the frames were 60 in. in height.

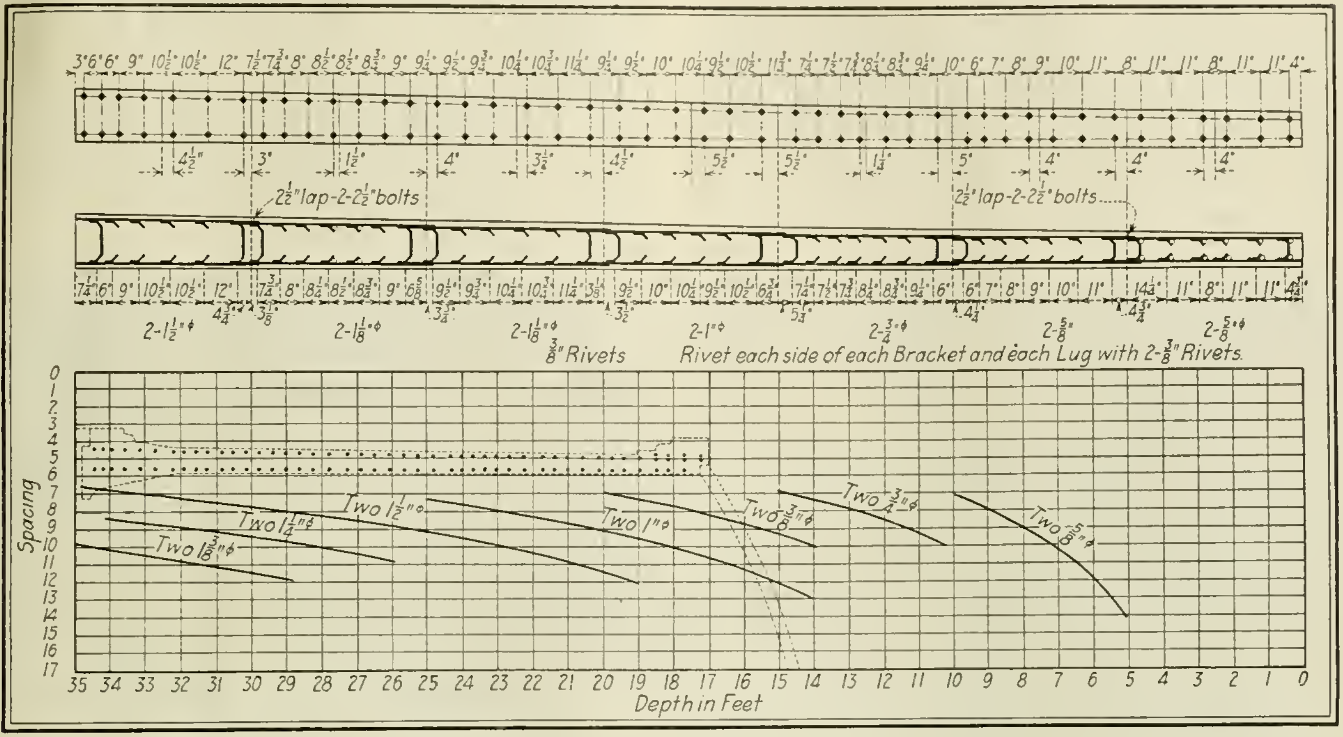


Fig. 1.—Spacing Diagram for Hoop Reinforcement for Reinforced Concrete Standpipes.

A steel stress of 12,000 lb. per square inch was assumed except for the base, with no value allowed for the concrete in tension. At the base, the allowable working stress was dropped to 8,000 lb. per square inch, to compensate in a measure for the uncertain stresses which are undoubtedly developed at the juncture between the side walls and the bottom of the standpipe. Besides increasing the metal at this point, a considerable amount of extra thickness of concrete was added and in addition to both these precautions, 48 1 in. square twisted rods, 11 ft. long bent 90° around a 10-in. radius, with vertical legs 36 in. long were placed at the point of juncture, between the bottom and side walls of the standpipe.

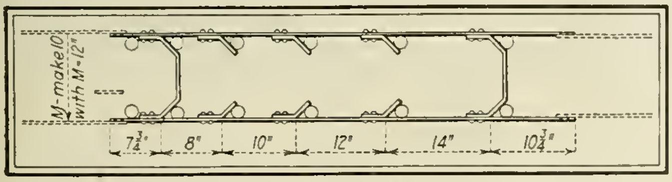


Fig. 2.—Reinforcement Spacing Frames for Reinforced Concrete Standpipes.

The spacing diagram for the reinforcing rods in the side walls was plotted from a computation of ⅝ in., ¾ in., ⅞ in., 1 in., 1⅛ in., 1¼ in. and 1⅜ in. diameter. As before mentioned, larger rods were actually used at the bottom of the side walls, to reduce the stresses to approximately 8,000 lb. per square inch.

The spacing diagram was computed on a basis of 12,000 lb. per square inch as follows:

Double spacing, i. e., two rods side by side.

$f2t = Pd.$

$ft = Pr = 0.434\ hr.$

$Af = 0.434\ hr.\ S \times 12.$

$Af = A \times 12{,}000.$

$$S = \frac{Pd \times 12}{2}.$$

$$S = \frac{2f\,A}{12\,pd} = \frac{f\,A}{6 \times 0.434\,h \times d} = \frac{12{,}000\,A}{2.6\,hd} = 115\frac{A}{h}.$$

In which:

A = Area of two rods per vertical foot of tank.
f = Stress of rods in tension.
t = Thickness of equivalent steel standpipe.
P = Pressure in pounds per square inch.
d = Diameter of tank in feet.
r = Radius of tank in feet.
n = Head of water in feet.
S = Spacing of rods in inches.

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## A $4,000,000 WATER SUPPLY DEVELOPMENT FOR SEATTLE, WASH.

The City of Seattle, Wash., is contemplating making improvements to its water supply system that will call for an expenditure of several million dollars. It is probable that bonds will be voted this fall to begin construction on a part of the development.

The present supply is obtained from the Cedar River at Landsberg, and is carried to the city by two pipe lines, one about 28½ miles in length, the other about 24½ miles in length. The distribution system is divided into three zones. The lower zone is supplied from three low service reservoirs of a total capacity of 183,000,000 gal. The intermediate zone is served by two reservoirs of a total capacity of 83,000,000 gal. The high service zone, comprising a comparatively small area, is fed from standpipes supplied by pumping from the intermediate or low service reservoirs. The population is about 300,000. The present consumption during the period of greatest use of water in the summer time is about 42,000,000 gal. per day, or 140 gal. per capita per day.

An investigation of the situation has been made by Mr. A. H. Dimock, City Engineer, and Mr. L. B. Younger, Superintendent of the Water Department, and a joint report on the matter was submitted on June 15 to the City Council. In this the following tentative plan was submitted for developing a supply of 150,000,000 gal. per day. The successive links in this development are as follows:

First—The construction of a concrete aqueduct from the intake to Swan Lake, including the necessary diversion and intake works. Second—The creation at Swan Lake of a storage reservoir of large capacity. Third—The construction of a concrete aqueduct from Swan Lake to Molasses Creek, or of a tunnel from the northwest corner of Swan Lake. Fourth—The construction, as may be needed, of two additional pipe lines from end of aqueduct or tunnel to the city reservoirs. Fifth—The reconstruction, as may be needed, of the two existing pipe lines between Swan Lake and the city reservoirs. Sixth—The construction, within or near the city limits, of additional reservoirs. Seventh—The construction of such additional links as are necessary to complete the main distribution service.

The estimated cost of the complete system is as follows:

| | |
|---|---|
| Concrete conduit, Landsberg to Swan Lake, including rebuilding of intake | $ 573,000 |
| Development of Swan Lake, including aqueduct to Molasses Creek | 777,000 |
| Replacing No. 1 Line with steel | 625,000 |
| Replacing No. 2 line with steel | 1,180,000 |
| Steel pipe line No. 3, Molasses Creek to West Seattle | 1,650,000 |
| Steel pipe line No. 4, Molasses Creek to Volunteer Park | 1,600,000 |
| Enlarging Volunteer Park Reservoir | 190,000 |
| Enlarging Lincoln Park Reservoir | 70,000 |
| Reservoirs at West Seattle | 483,000 |
| Distribution | 1,034,000 |
| Total | $8,182,000 |

It is stated that in case the existing wood pipe lines Nos. 1 and 2 are rebuilt in wood and not replaced with steel pipe the total cost would be reduced to $7,178,000. An estimate also was submitted of the cost of enlarging the present system to a capacity of 150,000,000 gal. per day. This plan does not include the use of Swan Lake. The total estimated cost of this plan is $10,127,000.

The scheme recommended calls for the following successive steps:

1. Complete the rebuilding of Pipe Line No. 1 in wood. 2. Increase the capacity of Volunteer Park Reservoir. 3. Acquire and develop Swan Lake, including necessary lands and rights of way. 4. Build Pipe Line No. 3 of steel, from Molasses Creek to West Seattle. 5. Acquire sites and construct the West Seattle reservoirs. 6. Construct new distribution mains. 7. Rebuild Pipe Line No. 2 in wood or steel, as experience may dictate. 8. Construct a single conduit from Landsberg to Swan Lake when necessary because of the need of additional supply or because of failure of present pipe lines. 9. Construct Pipe Line No. 4 from Swan Lake to Volunteer Park.

The above would be the entire program for developing a supply of 150,000,000 gal. per day. The cost of the first seven items enumerated above, not including the reconstruction of Pipe Line No. 1, amounts to $4,205,000. It is stated that this expenditure should be authorized at this time. The making of these expenditures, however, would necessarily be distributed over a period of three to five years. The essential features of this plan of development are the acquisition and improvement of Swan Lake, the enlargement of the Volunteer Park Reservoir, the construction of Pipe Line No. 3, and the construction of the new reservoirs in West Seattle. This work, the report states, should be inaugurated as soon as possible and pushed to completion.

## MACHINE MOWING IRRIGATION CANAL BANKS.

Tests made in the Salt River Project, U. S. Reclamation Service, have proved the feasibility of machine mowing irrigation canal banks. Mr. J. A. Haltom, project manager, in the "Reclamation Record," states:

The main point considered in the selection of the new mower is to get a machine with the greatest downward drop to the cutting bar so that weeds on the sloping banks can be mowed satisfactorily. It is also necessary to have the wheels equipped with right-angle lugs to prevent sliding or skidding on slippery banks. After using these machines for one season the following facts have been established:

First. It is necessary to have a good teamster skilled in adjusting his machine so it will cut under various and difficult conditions. A quiet, steady team is also essential.

Second. It is practicable to use mowing machines on canal banks where the slope does not exceed 45°.

Third. Machines cannot be operated on banks where there is trash or heavy brush.

Fourth. Leveling the banks when the ditches are being cleaned greatly increases the efficiency of the machine.

Fifth. Mowing should be done in the early part of the season when the grass and weeds are tender and standing straight. If the work is delayed until late in the season the weeds fall and make the work more difficult.

Sixth. One mowing machine working under normal conditions will do the work of from 8 to 14 men using scythes, thus effecting a saving of from $10 to $20 per day.

Seventh. With careful driving, machines can be operated in difficult places.

At the end of the season the machines were in good condition and required very little repair. On several occasions team and machine slipped off the bank into the canal, but no serious damage resulted.

## SOME STATISTICS OF CANADIAN WATER WORKS.

The accompanying tabulations show interesting data respecting Canadian water works. They are taken from the report of the Commission on Conservation Relating to Water Works and Sewerage Systems, and are self-explanatory:

TABLE I.—TOTAL COST OF WATER WORKS, MAINTENANCE CHARGES, CONSUMPTION, ETC., FOR THE DIFFERENT PROVINCES.

(In this compilation the items which it was impossible to obtain from the municipalities have been estimated and included.)

| Province. | Cost of plants (dollars). | Total daily consumption (imp. gal.). | Annual maintenance exclusive of interest (dollars). | Total length of mains (miles). | Daily cons'ption per capita (imp. gal.). | Estimated cost per 1,000 gal.* (cents). | Est. cost per capita per year* (dollars). |
|---|---|---|---|---|---|---|---|
| Nova Scotia | 5,046,375 | 23,450,000 | 186,178 | 431 | 127 | 8.1 | 3.73 |
| Prince Edw. Island | 341,119 | 933,000 | 15,953 | 30 | 54 | 14.7 | 2.91 |
| New Brunswick | 3,920,429 | 14,580,000 | 114,491 | 213 | 143 | 9.5 | 4.96 |
| Quebec | 36,087,735 | 140,218,000 | 941,654 | 1,545 | 120 | 8.9 | 3.90 |
| Ontario | 44,506,759 | 169,554,000 | 1,821,205 | 2,643 | 116 | 10.1 | 4.30 |
| Manitoba | 8,378,491 | 10,740,000 | 486,414 | 388 | 50 | 33.8 | 6.22 |
| Saskatchewan | 6,339,258 | 7,866,000 | 296,702 | 327 | 55 | 32.4 | 6.54 |
| Alberta | 8,089,523 | 23,789,000 | 271,245 | 520 | 121 | 12.4 | 5.51 |
| British Columbia | 11,015,944 | 35,747,000 | 424,697 | 1,052 | 100 | 11.7 | 4.29 |
| Canada | 123,725,633 | 426,877,000 | 4,558,539 | 7,149 | 111 | 10.9 | 4.12 |

*These costs are approximate only, and have been calculated from the annual maintenance costs, plus an allowance of 10 per cent of the cost of plants for interest and depreciation.

TABLE II.—NUMBER OF WATER WORKS PLANTS IN EACH PROVINCE, CLASSIFIED ACCORDING TO SOURCE OF SUPPLY, MODE OF SUPPLY, POWER USED, ETC.

| Province. | No. of plants supplied from— | | | No. of plants using— | | Mode of supply. | | Kind of power where pumping is used. | | | | | | | Ownership. | | Rates on which charges are made. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Springs or wells. | Lakes or streams. Distant. | Lakes or streams. Possibly Polluted. | Filters. | Hypo. | Gravity. | Pumped. | Water power. | Steam. | Electric. | Gas. | Gasoline. | Oil. | Wind. | Municipal. | Private. | Flat. | Meter. | Both F. and M. |
| Nova Scotia | 7 | 25 | 1 | 2 | .. | 22 | 11 | 2 | 8 | 1 | .. | .. | .. | .. | 30 | 3 | 20 | .. | 11 |
| Prince Edward Island | 3 | .. | .. | .. | .. | 1 | 2 | .. | 2 | .. | .. | .. | .. | .. | 2 | 1 | .. | .. | 2 |
| New Brunswick | 10 | 7 | 3 | 1 | .. | 9 | 11 | .. | 4 | 4 | 2 | .. | .. | 1 | 18 | 2 | 13 | .. | 6 |
| Quebec | 76 | 29 | 72 | 19 | 10 | 93 | [illegible] | 10 | 27 | 29 | .. | 5 | .. | 7 | 102 | 75 | 46 | 1 | 19 |
| Ontario | 66 | 6 | 94 | 27 | 10 | 23 | 143 | 18 | 66 | 41 | 8 | 3 | 2 | 1 | 148 | 18 | 76 | 6 | 70 |
| Manitoba | 6 | 1 | 6 | 5 | .. | 2 | 11 | .. | 5 | 2 | 1 | 2 | 1 | .. | 13 | .. | 1 | 6 | 3 |
| Saskatchewan | 21 | [illegible] | 7 | 6 | .. | 6 | 24 | .. | 4 | 11 | 2 | 4 | 3 | .. | 30 | .. | 10 | 11 | 4 |
| Alberta | 9 | 5 | 19 | 10 | 1 | 11 | 22 | .. | 16 | 2 | 2 | 1 | 1 | .. | 24 | 9 | 10 | 4 | 12 |
| British Columbia | 8 | 31 | 14 | 2 | .. | 46 | 7 | .. | 3 | 3 | .. | 1 | .. | .. | 29 | 24 | 33 | 2 | 14 |
| Canada | 206 | 106 | 216 | 72 | 21 | 213 | 315 | 30 | 135 | 93 | 15 | 16 | 7 | 9 | 396 | 132 | 209 | 30 | 141 |

## A PRELIMINARY REPORT UPON PURIFICATION OF SWIMMING POOLS OF THE STATE UNIVERSITY OF IOWA.

Contributed by Jack J. Hinman, Jr., Senior Water Bacteriologist and Chemist, Laboratories for the Iowa State Board of Health, State University of Iowa, Iowa City.

The plants for purifying the water of the two gymnasium swimming pools at the State University of Iowa were put into operation in January, 1916. In addition to their function in purifying the pool water, they are expected to be available for class use in hydraulics and water supply. With this in mind, the filter at the men's gymnasium was made of the pressure type and that at the women's gymnasium of the gravity type. Both filters are equipped with coagulant-dosing devices, loss-of-head gages and small wall-bracket chlorine apparatus for the application of liquid chlorine. The University purchased both plants of the Pittsburgh Filter Co.

The men's pool is 60x30 ft. in plan and varies from 4 ft. to 8 ft. in depth. It has a capacity of 89,100 gal. The women's pool is 60x24 ft. and from 3.9 ft. to 7.8 ft. in depth. The men's pool reaches its maximum depth at 40 ft. from the shallow end of the pool, while the women's pool does not reach maximum depth until 55 ft. from the shallow end. In the latter pool there is a drop of only 1.7 ft. in the first 30 ft. The capacity of this pool is 61,200 gal.

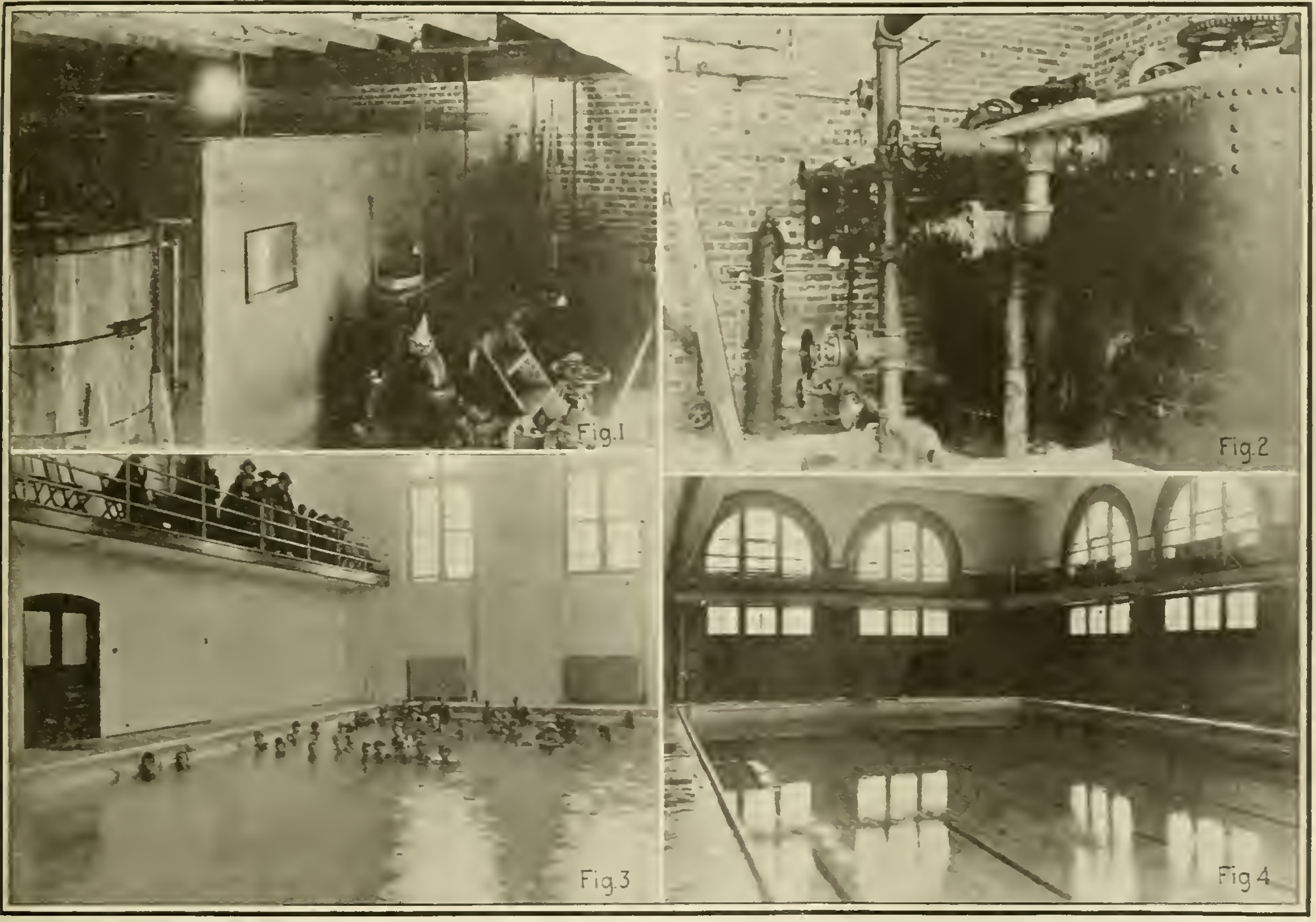


Fig. 1—Filters at the Women's Pool; Alum Tank in Foreground; Settling Basin; Filter Next to Wall. Fig. 2—Pressure Filters at the Men's Pool; Chlorine Apparatus on Wall to Left. Fig. 3—The Women's Pool; View Looking Toward the Shallow End. Fig. 4—The Men's Pool; Note the Clearness of the Bottom, Although it is Under 8 Ft. of Water; This Water Has Been in Use for Nearly Four Months.

Both pools are constructed of concrete faced with white enameled brick. Green enameled brick form division lines. An overflow trough, moulded to form a handrail, forms the edging of the pool. The water to be purified is withdrawn at the deep end of the pool and after purification is returned under water at the shallow ends. Both pools are housed in light rooms, open for two stories and furnished with galleries for spectators.

The pressure filters at the men's gymnasium are in duplicate. A filter bed consisting of 8 in. of gravel and 28 in. of sand is enclosed in a steel shell 5 ft. in diameter, 6 ft. 8 in. high over all. Hand-operated rakes are provided for agitation. The liquid chlorine apparatus is the manufacturer's type "D." The alum solution tank is of wood, 2 ft. 6 in. in diameter and 2 ft. 6 in. high. The orifice boxes are of the usual type, of enameled iron 10x25x8 in. An electrically driven pump furnishes 200 gal. of water per minute. The contract specifies a rate of 2 gal. per minute per square foot of filter area or 116,000 gal. per day.

The gravity filter at the women's gymnasium consists of a single concrete filter tank 6x8 ft., 6 ft. 9 in. deep. The filter bed is 10 in. of gravel and 2 ft. 6 in. of sand. The overflow of filter is set 5 ft. 3½ in. from the floor. A baffled sedimentation basin 6x10 ft., 6 ft. 9 in. adjoins the filter. The alum and chlorine apparatus are as above described for the pressure filters. The gravity filter, operating at a rate of 2 gal. per minute per square foot of filter area, will filter 138,240 gal. per day.

The temperature of the water returned to the pools is regulated by means of steam-heating devices housed in the filter rooms. These devices are controlled by thermostat. A temperature of 76° F. is maintained in the water of the men's pool and a temperature of 84° F. at the women's pool.

The contracts with the filter company call for the degree of purification usually specified for water purification plants by companies engaged in their construction. The number of bacteria growing at 37° C. is guaranteed not to exceed 100 per c. c. when the number of bacteria in the raw water does not exceed 5,000 per c. c. When the raw water exceeds 5,000 per c. c. a bacterial reduction of 98 per cent is guaranteed. The filtered water is guaranteed to conform to the Government's standard for water supplied to passengers in interstate traffic as regards the content of B. coli. A certain amount

Tests: January 21 to May 18, 1916.

| Pool. | Av. temp. F°. | Bacteria per c.c. in 37° litmus laclose agar. |  | B. coli in 1 c.c. (times found). | Bacteria per c.c. at 20° C. on plain nutrient agar. |  |  |  |  | No. of persons using pool in 1 day (approx.) |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  | 0 to 99 | 100 to 500 |  | 0 to 499 | 500 to 999 | 1,000 to 9,999 | 10,000 to 19,999 | 20,000 to 30,000 |  |
| Men's | 76 | 80 | 3 | 7 | 4 | 9 | 38 | 20 | 16 | 200 |
| Women's | 84 | 65 | 18 | 3 | 55 | 6 | 20 | 6 | 15 | 225 |

of water is removed each day in washing the filters and fresh water from the mains added to an equivalent amount.

The chemicals used are aluminum sulphate, or "filter alum" and liquid chlorine. We have used an average of about 4 lb. aluminum sulphate per day for each pool. At times we have used more, the maximum being 10 lb., which was used at the men's pool. The minimum alkalinity of the pool water has been 122 p.p.m. We do not know so exactly the amount of liquid chlorine as we have not had platform scales available and our relative dosage is small. At first we tried to use a very small continuous stream of chlorine, but owing to the difficulty of regulation, we abandoned the procedure. We then added a much larger dose of chlorine at night and omitted chlorine entirely during the day. This was more satisfactory to the users of the pool and seemed to give us better results. We have also used copper sulphate at times when our chlorinator valves were leaking. While we have not made a complete enough study of the efficiency of copper sulphate to make a definite statement, we believe that our results with liquid chlorine have been more satisfactory.

It is hoped that a number of small improvements may be made in the plants during the summer. There should be provided a means of wasting the first water to flow through the filter and there should be a series of pet cocks put in so that samples of the water can be taken more conveniently.

During the period of the tests reported herein (Jan. 21 to May 18, 1916), the pools were not emptied, although, as mentioned above, fresh water was added at the time of filter washing. Filters were washed every day during the greater part of the run. The physical improvement of the water can best be seen by an examination of the photograph of the men's pool. The water is at rest. The bottom lines appear sharp and clear, although they are beneath 8 ft. of water. Shower baths with soap are required to be taken by each person before using the pool. A certain amount of sediment collects on the bottom of the pool, in spite of this precaution. This sediment is removed by sweeping it toward the outlet pipes with brushes weighted with lead weights.

The samples reported upon were taken near the shallow ends of the pools. A number of samples were secured at the deep ends, near the bottom, at the surface, etc. We have not done this sort of sampling systematically and we therefore plan to repeat this work next year in a systematic manner. A sample of water was taken from each pool daily, except holidays and during spring vacation. The figures given in the table record the number of times the bacterial counts were found within the given limits. At no time were the limits set forth in the table exceeded. It is interesting to note that, although tests were made daily for 83 days, the colon bacillus was found in 1 c. c. by presumptive test on but seven days in the men's pool and on but three days in the women's pool. It is also noteworthy that in the warmer women's pool the number of organisms growing at 37° C. was larger and the number of organisms growing at 20° C. was smaller than in the cooler, men's pool. The difference in temperature was only 8° F.

In spite of the difficulty which we have in controlling our supply of chlorine, the results obtained seem to be quite satisfactory. We consider that in the purification the 37° C. count is much more significant than the 20° C. count.

The operation of the two plants and the examination of the samples was carried on under my direction by Mr. Harold Barber, a junior student in the College of Applied Science. Mr. Barber will continue the work next year and will embody the results in his thesis.

## A HANDY CHART FOR FIGURING POWER CAPACITY AND EFFICIENCY OF PUMPS.

Contributed by W. F. Schaphorst, Woolworth Building, New York, N. Y.

This chart will be found useful for finding the horse power necessary to do almost any pumping job up to 100 h.p.; for finding the gallons of water a given pump will lift per minute; for finding the head; or for finding the efficiency of a given installation.

For example, how many gallons per minute will be pumped by a 40 h.p. motor through a 40-ft. head, the efficiency of the pump being 50 per cent? Join the 40 (column A) with the 50 per cent (column E) and locate the instruction with column C. Then run a straight line through that intersection (column C) and the 40 (column D) and the answer (1,950 gal. per minute) is found in column B.

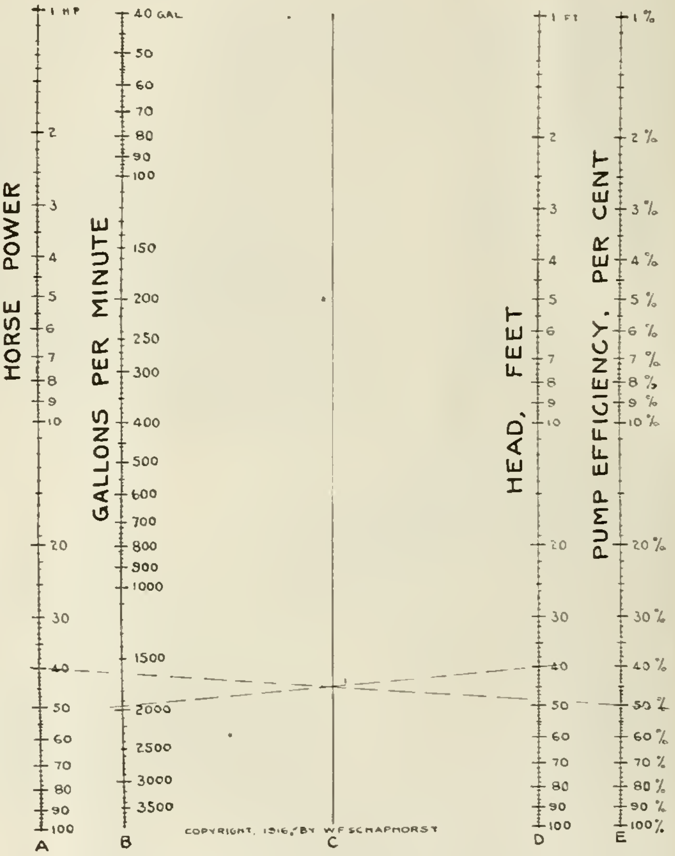


Chart for Computing Power, Capacity, Etc., of Pumping Plant.

The principal point to remember is—always connect A and E; B and D. The two outside columns must be used together, and B and D must be used together.

It is plain, now, that knowing three of the values in A, B, D or E, the fourth one is easily and quickly found without any computing.

Whether the motive power is electric, steam, gas, or water, makes no difference. And it doesn't matter about the pump either—whether duplex, triplex, reciprocating steam, centrifugal or air lift.

When figuring efficiencies I usually allow about 80 per cent for duplex, triplex, and reciprocating pumps in general; a good modern centrifugal pump, about 60 per cent; and for air lift pumps, 40 per cent is considered pretty good. Higher efficiencies than these have been attained with all of the above pumps, to be sure. If you know the exact efficiency of your pump or the pump you have in mind, that is the efficiency to use in the chart, of course.

## SEWER CLEANING MACHINE USED AT HAMMOND, IND.

The illustrations show a sewer cleaning device used successfully for a number of years at Hammond, Ind., and developed by John F. Kuhlman, head of the department of public works of that city. The diagram, Fig. 1, depicts the operation of cleaning a sewer. The bucket, shown by Fig. 2, is introduced at manhole A and pulled ahead by the machine at manhole B until filled; if working nearest manhole A the pull is then reversed, closing the front conical cutters and the bucket lifted out at manhole A; if working nearest manhole B the filling pull is continued until the bucket reaches manhole B and is hoisted out, then it is hauled back toward A for a new load. Figure 3 shows one of the windlass trucks. The jaws of the bucket have sharp cutting edges and also close strongly, making them, it is claimed, capable of cutting root masses that have grown into the sewer. Buckets are made in five sizes for sewers from 12 in. up in diameter. A feature of the device is the manhole sheave jack and arm; the sheave arm being hinged tilts back when the bucket strikes it and guides the bucket out of the manhole without fouling. This cleaner has been placed on the market by the Champion Potato Machinery Co., Hammond, Ind.

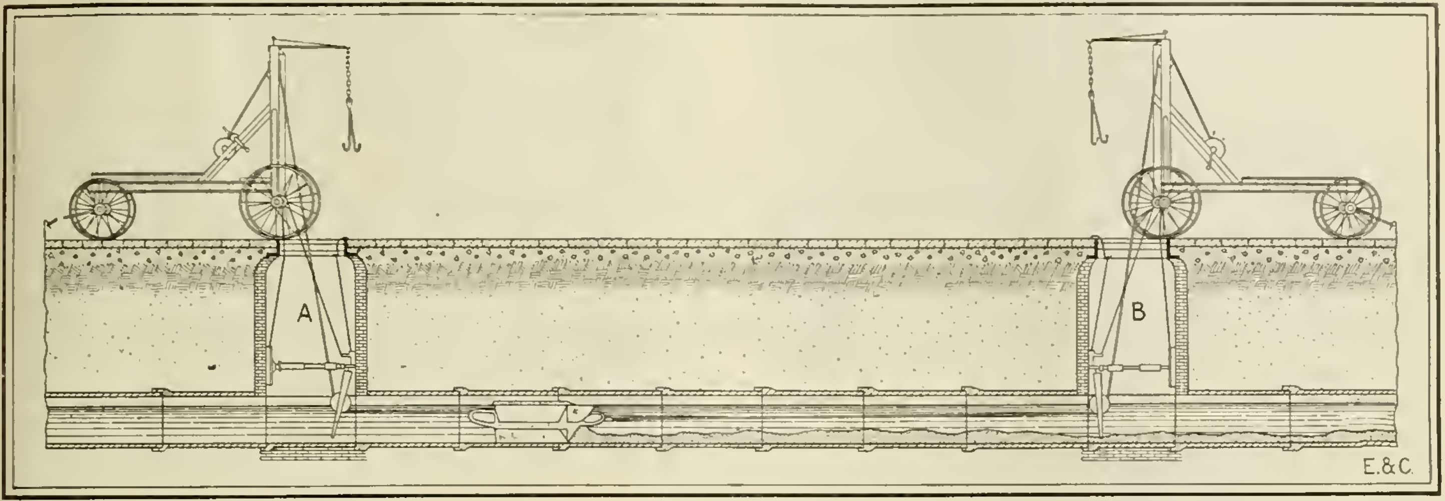
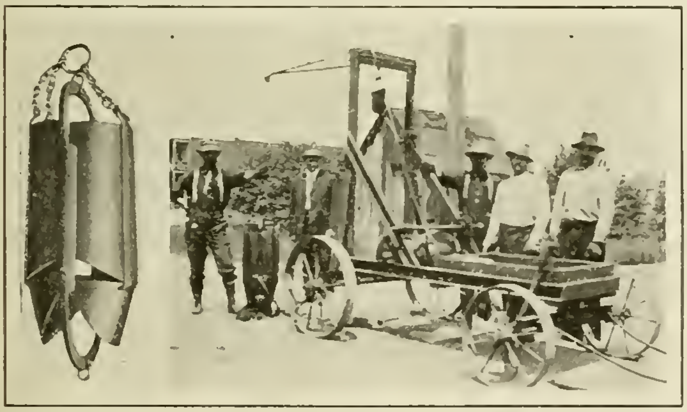


Fig. 1—Diagram Showing Operation of Cleaning a Sewer With a Kuhlman Sewer Cleaning Machine.



Figs 2 and 3—Cleaning Bucket and Windlass Truck, Kuhlman Sewer Cleaning Machine.

## TESTS SHOWING HIGH AIR LIFT PUMP EFFICIENCY.

(Contributed.)

In January, 1915, a series of experiments was undertaken by L. T. Edwards & Co., of Philadelphia, for the purpose of developing, if possible, a more efficient air lift for pumping deep wells. After several hundred experiments with different commercial air lifts and various experimental forms, a design embodying some radical changes from the commercial types was developed, and very gratifying results were obtained.

The new design is known as the Talbot Compound Air Lift System and is now in use in the Gloucester City, N. J., water works, the Camden, N. J., water works and in many industrial plants and institutions. Messrs. Edwards & Co. gave the city of Camden a guarantee to pump their wells at a rate of 50 per cent more water per cubic foot of air used than was obtained by their old equipment. The first well equipped showed 67 per cent, the second well, which had a well-known, patented lift, showed 189 per cent, and the third well showed over 100 per cent. These old lifts were all standard designs, generally considered good.

It is, however, the absolute and not the relative performance which appeals most strongly to the engineer. The accompanying Table I gives the performance of the Talbot System in one of the Camden wells.

The air was measured with a General Electric air flow meter, and the water was measured by pumping into a 1,000-gal. tank for an interval of time measured with stop watches. The accompanying curves were plotted from the table. The normal output of the well was about 300 gal. per minute and the efficiency at this point was very nearly 60 per cent. This efficiency is over all from the steam end of the compressor. Fifteen per cent was

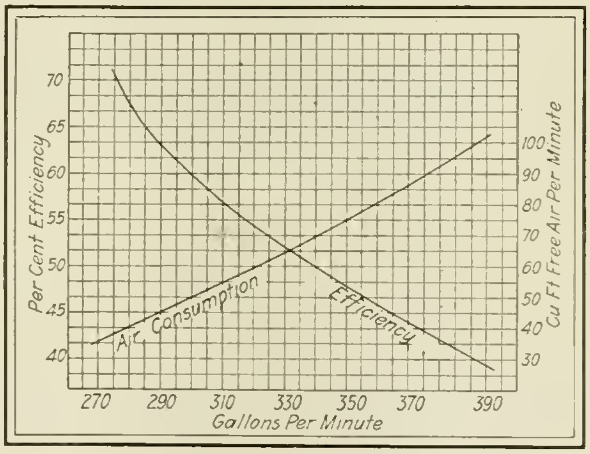


Diagram of Air Lift Pump Efficiency.

TABLE 1.

| Cu. ft. free air per min. | Gal per min. | Static pres. | Pres. at well top. | Cu. ft. air per gal. | Submergence, per cent. | Lift in ft. | Water, HP. | Air, HP. | Efficiency, per cent. |
|---|---|---|---|---|---|---|---|---|---|
| 50 | 300 | 31.5 | 35.3 | .166 | 63 | 42.8 | 3.22 | 5.40 | 59.6 |
| 60 | 322 | 31.0 | 35.5 | .186 | 62 | 43.9 | 3.56 | 6.54 | 54.2 |
| 100 | 392 | 27.5 | 37.5 | .255 | 55 | 52.0 | 4.55 | 11.30 | 40.2 |

1. Depth of well, 120 ft.
2. Diameter, 8 in. ⅛
3. Surface to foot-piece, 106 ft.
4. Foot-piece to point of discharge, 115.5 ft.
5. Eduction pipe, 5 in.
6. Air pipe, 1¼ in.

added to the theoretical air horsepower to allow for friction. The curves show that when the well is forced beyond the normal output, the efficiency falls off rapidly. This is due to the increase of water friction with the higher velocity and to the decreased submergence.

The unprecedented efficiency obtained by the Talbot lift is due to a large number of small refinements in design and construction and a few radical ones. The lift is not simply a foot-piece and well top, but comprises a specially designed and constructed eduction pipe, which is always included as a part of the regular equipment furnished.

## AN OLD AND A NEW REGULATING DAM CONSTRUCTION, ERIE CANAL, NEW YORK.

At Tonawanda, N. Y., at the western end of the Erie Canal, a regulating dam across Tonawanda Creek controls the Lake Erie level extending from Buffalo to Lockport. The first dam was built in 1825 and was a timber structure with masonry abutments. A section at the center of this old dam is shown by Fig. 1A. As will be seen rather primitive construction was adopted, but it endured nearly a century. In December, 1915, this old dam was washed out and to make ready for canal navigation in May, 1916, a substitute structure capable of rapid construction had to be designed. Figures B, C and D show the design developed.

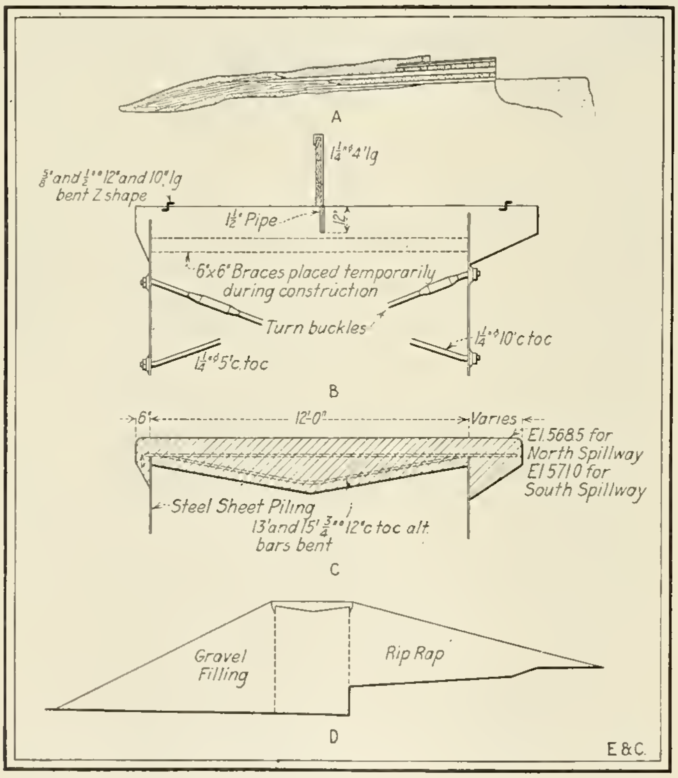
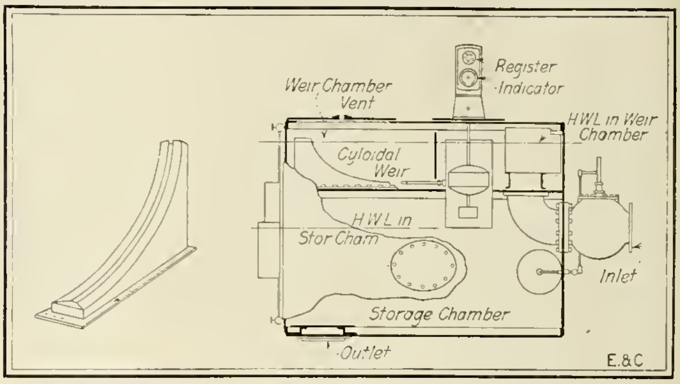

A
1¼"ϕ 4' lg
⅝" and ½"ϕ 12" and 10" lg bent Z shape
1½" Pipe
12"
6"x6" Braces placed temporarily during construction
Turn buckles
1¼"ϕ 10' c to c
1¼"ϕ 5' c. to c
B
6"
12'-0"
Varies
El. 568.5 for North Spillway
El 571.0 for South Spillway
Steel Sheet Piling
13' and 15' ¾"ϕ 12" c to c alt. bars bent
C
Gravel Filling
Rip Rap
D
E&C

Fig. 1—Details of Regulating Dam for Erie Canal at Tonawanda, N. Y. A, Section of Old Dam Built Prior to 1825; B, Section Showing Flashboards and Pile Bracing; C, Section of Concrete Cap; D, Typical Section of Completed Dam.

Two parallel rows of Lackawanna sheet piling 12 ft. apart were driven out shore from bank bulkheads to meet at an angle pointed upstream. The stream bottom is clay over hardpan and piles 25 to 35 ft. long were driven using a floating driver. The space between piles was filled with gravel and a gravel filling was placed on the upstream side and a riprap embankment on the downstream side. Over the sheet piles was a concrete cap. A typical section is shown by Fig. 1D, but the section varied from point to point. The concrete cap structure is shown in detail by Fig. 1C. A feature to be noted is that the north part of the spillway has a crest elevation 1½ ft. higher than the south part. Along the south spillway provision is made for flash boards as indicated by Fig. 1B. The flash boards were cleated shutters made of three 2x10-in. planks 12 ft. long and each shutter was supported by three hooked rods set in pipe sockets molded into the concrete 5½ ft. apart. To brace the sheet piling a diagonal bracing of turnbuckle rods was used, as shown by Fig. 1B. At the ends of the dam are steel sheet pile bulkheads. The contractor for the dam was the Henry P. Burgard Co., Buffalo, N. Y., with Charles A. Dennis, Buffalo, N. Y., as subcontractor for pile driving. The dam was designed by the New York State Engineer Office; B. E. Wiling was resident engineer and to him we are indebted for the material for this article.

## A WEIR METER WHICH GIVES FLOW DIRECTLY PROPORTIONAL TO HEAD OF WATER.

In registering or recording the flow of water through the ordinary weir meter a complex mechanism is necessary because the discharge of the weir is in proportion to an odd power of the head. The sketches show a weir and assembled weir meter which eliminate these objections. As shown by the assembled sketch the meter box is divided into an upper and a lower chamber. Water enters the upper and is stilled by baffle plates before coming to the weirs at the end opposite the inlet valve. As many weirs are used as the volume to be metered demands. Through the weirs the water enters the lower chamber in which is the outlet. Suitable indicators, registers, recorders and gage glasses complete the meter. The vital feature of the meter is the cycloid weir. From the sketch it is clear how as the head or depth of water above the crest increases the area available for discharge is gradually reduced. By forming the weir to the proper curve, the discharge is made directly proportional to the head. This weir meter is made by the Kennicott Co., Chicago Heights, Ill.



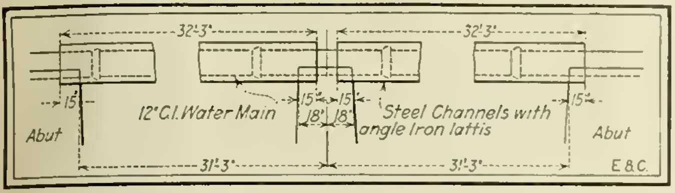
Proportional Weir Meter.

## GROUT WASHING INTERIOR OF BRICK LINED AQUEDUCT TO REDUCE LEAKAGE.

During September, 1915, the interior surface of the Wachusett aqueduct of the Boston and Metropolitan Water Supply of Massachusetts, crossing Assabet bridge was given two coats of Portland cement grout containing about 2 per cent of Medusa waterproofing compound, to determine its effect upon the leakage from the aqueduct at this place, which appears to take place through fine cracks in the brick lining. Before applying the cement grout the surface of the masonry was thoroughly cleaned with wire brooms and a strong solution of carbonate of soda. The section of the aqueduct treated is 353 ft. in length and about 1,100 sq. yd. of surface were covered at a cost of $240.99. While it is evident that a large portion of the leakage has been stopped, opportunity has not been had to make observations during freezing weather after the aqueduct has been flowing full for a few days.

## METHOD OF SUPPORTING AND INSULATING A CAST IRON MAIN CROSSING A BRIDGE.

The sketch shows the method of carrying a 12-in. cast iron water main across the Summer Creek bridge at Middletown, Conn. The bridge was of the reinforced concrete girder type in two spans, and the pipe was carried underneath between two girders, but independently supported on pier and abutments, as clearly indicated by the sketch. The pipe bridge in two spans consisted for each span of a box girder composed of two channels latticed top and bottom. Within the girder the pipe rested on saddles curved to the radius of the pipe and riveted to the bottom flanges of the channel. To protect the pipe from freezing it was wrapped with expanded metal on which was troweled first a coat of hair mortar and then a coat of cement and sand mortar, which was finally grout-washed with a brush. This covering forms a dead air space about the pipe which proved effective in the prevention of freezing of this water main. The velocity of water in the pipe is quite low during the hours of 1 to 5 a. m., but, notwithstanding this fact, it did not freeze last winter during temperatures as low as 10° below zero and a week of zero weather. Gordon Z. Smith, Superintendent of Water Works, Middletown, Conn., designed and installed the pipe crossing.



Method of Carrying Water Main Across Bridge.

## LAND RECLAMATION CONTEST FOR BOYS.

The Du Pont Company of Wilmington, Del., has just announced something entirely new in the agricultural line, that is, a Land Reclamation Contest. It should surely prove a success. There are millions of acres of land literally going to waste in this country today because of stumps, stones, boulders, swamps, gullies and other such conditions that handicap farming. All farmers know that with these troubles removed the ground can be turned into fertile, profitable fields. Many farmers are too busy with their present fertile land to bother with the waste acres, hence this contest is surely the boy of the farm's opportunity. It will give him a chance for greater development. All men, in any branch of life, know that the more responsibility you put on a person, especially a young man, the better he likes his work and the harder he works. Such should be the case with the above contest; it will increase his interest and have the tendency to keep him on the farm.

The idea of the contest is for the farmer to look over his farm and pick out the bad spots, then turn one acre of it over to his son, or another interested boy, and let him improve it.

If it is covered with stumps or boulders let him clear it. If it is swampy, let him drain it. Any method of reclamation is allowed. The company does not even insist upon the use of dynamite, although in most cases it has proven to be the most efficient method.

The main points of the contest are, to clear the land, improve the soil and then raise a crop. No special crop is specified, the only restrictions in the contest being that the work on the one acre must be planned and done or supervised by the boy himself.

The country has been divided into six sections and the following prizes will be awarded to the boys of each section showing the best results commensurate with cost:

North Atlantic States (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Ohio, Virginia, West Virginia):

| | |
|---|---|
| First prize | $50.00 |
| Second prize | 30.00 |
| Third prize | 20.00 |

South Atlantic States (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee):

| | |
|---|---|
| First prize | $50.00 |
| Second prize | 30.00 |
| Third prize | 20.00 |

North Central States (Illinois, Indiana, Iowa, Michigan, Minnesota, Nebraska, North Dakota, South Dakota, Wisconsin):

| | |
|---|---|
| First prize | $50.00 |
| Second prize | 30.00 |
| Third prize | 20.00 |

South Central States (Arkansas, Kansas, Louisiana, Missouri, Oklahoma, Texas):

| | |
|---|---|
| First prize | $50.00 |
| Second prize | 30.00 |
| Third prize | 20.00 |

Western States (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming):

| | |
|---|---|
| First prize | $50.00 |
| Second prize | 30.00 |
| Third prize | 20.00 |

Pacific Coast States (California, Oregon, Washington):

| | |
|---|---|
| First prize | $50.00 |
| Second prize | 30.00 |
| Third prize | 20.00 |

Besides the above cash prizes to winners they will present each contestant receiving honorable mention with a one year's paid subscription to any farm paper published in the United States—contestant to choose paper. The following conditions govern the contest:

The Du Pont Land Reclamation Contest for Boys will start officially at once. All entries must be received not later than January 1, 1917.

The contest will close December 1, 1917, and all reports must be in the hands of the Du Pont Agricultural Division, Wilmington, Delaware, before December 1, 1917.

Each entry blank provides for the official entry of only one (1) acre (43,560 sq. ft.) of ground. If a great number of acres are entered by any one contestant a separate entry slip for each acre so entered must be sent in.

Reports and records of each acre entered by a contestant will be required. Special blanks are provided for this purpose and will be sent upon receipt of entry blank.

In returning report blank for final award each report must be verified by the County Agricultural Agent or two neighboring farmers, not relatives.

This contest will surely stimulate the reclamation of much idle land, and being free from restrictions or "strings," will no doubt have the support and co-operation of all agricultural enthusiasts and workers.

## POWER DEVELOPMENT POSSIBILITIES OF COMPLETED RECLAMATION SERVICE PROJECTS.*

The United States Reclamation Service in the construction of irrigation works has on many of its projects a by-product in the shape of hydro-electric power, usually in blocks too small to be considered in connection with any extensive electrochemical industry, but in a few cases large enough to be thus utilized.

**Minidoka Project.**—On the Minidoka project in southern Idaho, the Reclamation Service has built a diversion dam which also provides considerable storage and a head of 46 ft. upon the wheels of a power plant constructed there with a capacity of 10,000 hp. This power is fully utilized during the summer months for irrigation pumping, and a large amount of power is still available for use in the winter. A further development of 10,000 hp. could be cheaply made which could be utilized the year around.

**Boise Project.**—In Idaho the Reclamation Service has built a high masonry storage dam about 240 ft. above the river bed. More than 1,000,000 acre feet of water have to pass this dam site every year, all of which is used for irrigation in minimum years, but in ordinary years there is considerable surplus. Power development at this dam could utilize the head in the reservoir which varies from 60 to 230 ft. The quantity of water available during the summer would be about 5,000 cu. ft. per second, which would be diminished in the spring and fall, and in the winter only about 200 cu. ft. per second could be drawn. Provision has been made for the convenient installation of power to the extent of 17,000 hp. at this site. A greater amount could be developed during the summer if found desirable.

**Pathfinder Dam, North Platte Project.**—The Pathfinder Dam on the North Platte River is 210 ft. high, forms a reservoir of 1,100,000 acre-feet, and intercepts an annual flow which varies from 1,000,000 acre-feet to over 3,000,000 acre-feet. The water of low and average years is all required for irrigation. It could be utilized for power as it comes from the reservoir, but would be available only six or eight months of the year, and the head would vary from 60 ft. to 200.

**Elephant Butte Dam, Rio Grande Project.**—A large amount of power is available during the irrigation season at the Elephant Butte Dam, but usually during two or three months of the winter no power is available.

The power is to be developed by using water drawn from the reservoir as needed for irrigation under the available head in the reservoir at the time drawn. The available head will vary from 65 to 185 ft., and the maximum quantity of water drawn will be about 2,500 cu. ft. per second. During eight months of the year it would be possible to develop from 20,000 to 30,000 hp., according to the head available and the quantity of water needed for irrigation.

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*Extract from a paper by Arthur P. Davis, Chief Engineer, U. S. Reclamation Service, before the American Electrochemical Society.

The development of power was considered in designing the dam and six 5-ft. power outlets were installed. The maximum output from these would amount to 12,000 hp. An 8,000 hp. plant has been estimated to cost about $420,000.

The construction of a hydro-electric plant for commercial purposes would be unattractive, as a large steam auxiliary would be required in order to operate in the winter when no water is drawn from the reservoir. The feasible power development, however, is well adapted to the needs of pumping for irrigation for which market exists within feasible transmission distance.

**Shoshone Project.**—On the Shoshone project a masonry dam has been constructed in the canyon of the Shoshone River about 250 ft. above the river bed. This dam furnishes a storage reservoir of about 450,000 acre-feet capacity and water is stored primarily for irrigation purposes. The flow of the stream, however, when thus regulated is greater than required for the irrigable lands and will furnish a surplus of water which can be used for power purposes during the winter. The river falls rapidly below the damsite, and it is easily feasible to develop power varying from 25,000 hp. in winter to 40,000 hp. in summer of average years.

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## THE CLEANING UP AND IMPROVEMENT OF A STREAM POLLUTED BY SEWAGE AND TRADE WASTES.

Contributed by Harrison P. Eddy, of Metcalf & Eddy, Consulting Engineers, Boston and Chicago.

For many years Massachusetts has taken an advanced position in the sanitary control of both inland and tidal waters. This is partly because of the density of population and the small size of the streams, which consequently afford comparatively little dilution for sewage and industrial wastes. Here, as in all other communities, the initial practice was to discharge raw sewage and untreated trade wastes into conveniently accessible waters. The result in several instances has been the creation of unsatisfactory conditions, sometimes of nuisances and occasionally of conditions popularly believed to be detrimental to the public health. The Neponset River is a good illustration of these conditions and of the improvements which may be made to alleviate them.

**Physical Features of Neponset River.**—The Neponset River rises about 22 miles from and discharges into Dorchester Bay, an arm of Boston Harbor. Its natural drainage area is 114.14 square miles. It also receives one-third of the flow of the Charles River at Dedham, equivalent to the drainage from 66.2 square miles. The total area tributary to the Neponset River at tidewater is therefore 180.3 square miles. There are several tributary streams, the largest of which is the Canton River, draining an area of 31.2 square miles.

In its upper and lower portions the river has a rapid fall, which early invited the construction of a number of dams for impounding water, which is now used principally, however, for technical purposes, although to some extent, for the development of power. The middle portion of the river flows through large areas of wet lands known as the Fowl Meadows, which have an area of 3,662 acres and are only about 13 miles from Boston.

The normal yield of the drainage area is probably about as follows:

| Month. | Mil. gal. daily. | Cu. ft. per sec. | Month. | Mil. gal. daily. | Cu. ft. per sec. |
|---|---|---|---|---|---|
| January | 216 | 334 | July | 31 | 49 |
| February | 304 | 470 | August | 45 | 69 |
| March | 492 | 762 | September | 40 | 62 |
| April | 356 | 551 | October | 76 | 117 |
| May | 190 | 294 | November | 135 | 209 |
| June | 84 | 130 | December | 176 | 272 |
| Mean | | | | 178 | 276 |

The actual flow is much more uniform than the natural flow would be, because of the regulating effect of the storage reservoirs.

**Population.**—The river flows through, or along the borders of, eight towns and the city of Boston. While the towns, with one exception, are small, the total population in the drainage basin is large, and at the lower end the river runs through a rather thickly populated suburban portion of Boston. In 1915 the aggregate population of the towns was about 45,000 and of the portion of the city of Boston lying within the drainage area about as many more.

**Sanitary Condition.**—The sanitary problem of the Neponset may naturally be divided into two parts—first, the drainage and reclamation of the Fowl Meadows and the general improvement of the physical condition of the channel and adjacent land; second, the treatment and disposal of trade wastes and sewage, so that they may not cause a nuisance or endanger the public health.

This river and the Fowl Meadows have been the subject of investigation by state authorities since 1873. The last report is that of the Commissioner of Health, issued under date of January 10, 1915, accompanied by the report of X. H. Goodnough, Chief Engineer of the Department of Health. Some of the data given in the following pages are taken from the latter report.

In 1875 the State Board of Health found, after an investigation of the river, and with the aid of a number of chemical analyses, that there was "no evidence that it was noticeably polluted at any point, unless perhaps in the vicinity of Walpole." The river at this time is said not to have been at the low state usual in a dry summer.

In 1885 "The odor of the river in the vicinity of the ink works is said to have been very bad."

As a result of an extended investigation, the Board reported in 1891 that "The Neponset River, though not wholly free from pollution by the waste products of human life, even in its upper portions, is pre-eminently a river which is polluted by manufacturing wastes." (Mass. St. Bd. Health Rept. 1891, p. 328.) The Board at this time laid considerable emphasis upon the large dark patches of floating mud seen upon the surface of millponds and the river. In one pond it is said that the patches of floating matter sometimes covered half an acre or more. Usually it did not exceed an inch in thickness, but in one case it measured 3 in. in thickness.

Again in 1895 another examination was made and the Board found the condition of the river to be much worse than in 1891.

> From Pleasant Street to Canton River the water was very dirty and carried a large amount of suspended matter, and floating upon its surface was an enormous number of the pieces of black referred to. The banks and bottom were covered with slime and refuse from manufacturing establishments above, and the odor of the stream was very offensive. Near Canton River the current slackens and some of the suspended matters are deposited, so that the bottom of the river for a long distance above and below Canton River is covered with decomposing organic matter, from which bubbles of gas rise to the surface. The floating patches of organic matter were much more numerous than in 1891, and these and probably other organic matter collecting in the coves and bays along the river through the great meadows make them extremely offensive, particularly when the water is low and the mud flats are exposed. The river was very turbid and had a strong and very offensive odor nearly the whole length of its course through the great meadows. . . . The odor in Hyde Park was extremely offensive from the numerous drains and privies along the banks of the stream.—(Mass. St. Bd. Health, Spec. Rept. on Neponset Meadows, 1897, p. 11.)

In 1897 only about one-sixth of the area of the meadows was in a condition adapted to profitable agriculture. They appeared to have been growing worse and many of the larger owners had abandoned the attempt at drainage by open ditches on account of the steadily diminishing returns from crops. As regards health, the Board found that for years there had existed a popular belief that the meadows had become a source of sickness; that "intelligent observers report that these meadows are at times the source of disagreeable odors and the direct cause of much sickness" (Mass. St. Bd. Health Rept. 1916, p 17), and that "the upper portion of the stream was very seriously polluted." For these several reasons and in spite of convenient transportation facilities, a tract of 11 square miles, comprising meadows and neighboring upland, at an average distance of 13 miles from the State House in Boston, is uninhabited.

To remedy the insanitary conditions, the Board recommends:

> First.—Such additional legislation as will prevent the entrance into this stream of sewage and manufacturing wastes which have not been satisfactorily purified.
>
> Second.—The permanent removal of the flashboards of the dam of the Mattapan Mills, the enlargement of the cross-section of the river at points indicated on Plan No. 3, together with a deepening and reconstruction of the channel at such places as may be found necessary for making a channel of such width and grade as will prevent the flooding of the meadows during the times of high flows in late spring and summer. . . .

**Drainage of Fowl Meadows.**—The second measure, authorized in part in 1911, has been nearly completed by the State Board of Health and its successor, the State Department of Health.

The length of the old main and tributary river channels, covered by this work, is 12.81 miles. The improvement in alignment has shortened the channel 1.56 miles. The new main river channel has a capacity sufficient to carry, without overflowing its banks, a quantity of water equivalent to 4 cu. ft. per second per square mile of tributary drainage area; the slope of its bed is 0.58 ft. per mile; the total fall of the water surface with a flow of 4 cu. ft. per second per square mile, is 4.5 ft., equivalent to 0.41 ft. per mile, and the surface of the water in the channel under these conditions is from 1.1 to 1.8 ft. below the general level of the surrounding meadows.

The cost of this undertaking has been $202,765.98, of which a sum of only $3,505.96 is chargeable to the land damage account. The State has defrayed the expense of this improvement, in the first instance, but the statute provides that one-half of the said expense shall be repaid to the commonwealth by the eight towns and the city of Boston, which shall also pay the cost of maintenance of the channel of the river and the works or structures taken or otherwise acquired in connection therewith. The towns and the city of Boston are in turn required to assess the amount paid to the commonwealth upon the land benefited, in proportion to the betterment thereof.

**Additional Drainage Improvements.**—To complete and render fully effective the improvement of the channel already nearly completed, additional drainage ditches must be excavated, which, with other work required, is estimated to cost $58,910. The improvement of the river channel and adjacent lands from the Fowl Meadows down to the dam at tidewater have been estimated to cost $95,277.50. The work covered by this latter estimate will provide a more satisfactory river channel and eliminate, by filling or draining, certain mosquito-breeding swamps.

**Total Cost of Drainage Improvements.**—Should the Legislature decide to complete all of the work reported upon by the State Department of Health, the probable cost will be about $362,000. If subsequent statutes provide for the assessment of betterments to the same extent as the statutes already passed, the cost to the State will be about $181,000 and an equal amount to the property owners benefited. The amount already expended is but $202,765.98, however.

**Prohibition of Pollution of River.**—Pursuant to the first of the two recommendations of 1897, the Massachusetts Legislature in 1902 passed a statute prohibiting the pollution of the Neponset River and its tributaries; sections 1 and 2, here quoted, are of particular interest:

> Section 1. The State Board of Health is hereby authorized and directed to prohibit the entrance or discharge of sewage into any part of the Neponset River or its tributaries, and to prevent the entrance or discharge therein of every other substance which may be injurious to public health or may tend to create a public nuisance, or to obstruct the flow of water, including all waste or refuse from any factory or other establishment where persons are employed, unless the owner thereof shall use the best practicable and reasonably available means to render such waste or refuse harmless.
>
> Section 2. The Board shall consult and advise with any such owner at his request or of its own motion as to the best practicable and reasonably available means of rendering such waste or refuse harmless, having regard to the circumstances and requirements of the situation and to the industrial interests involved.—(Chap. 541, Acts of 1902.)

This statute empowered the courts to enforce its provisions and any order made by the State Board of Health in conformity therewith, proceedings for enforcement to be instituted and prosecuted by the attorney-general upon the request of the State Board of Health or of any other party in interest.

In 1906 the Legislature passed an act, Chap. 360, amending the Act of 1902. Sections 1 and 2 of the Act of 1902 were amended so as to read as follows:

> Section 1. The State Board of Health is hereby authorized and directed to prohibit the entrance or discharge of sewage into any part of the Neponset River or its tributaries, and to prevent the entrance or discharge therein of every other substance which may be injurious to public health or may tend to create a public nuisance.
>
> Section 2. The Board shall consult and advise with the owner of any factory or other establishment, at his request or its own motion, as to the best practicable and reasonably available means of rendering the waste or refuse therefrom harmless.

The provision for the enforcement of the act was not materially altered, but a penalty was provided for failure to comply with its provisions. It was the evident intention of the original act to have reasonable regard for manufacturing industries. The section providing the penalty is as follows:

> Section 4. Whoever permits the entrance or discharge into any part of the Neponset River or its tributaries of sewage or of any other substance injurious to public health, or tending to create a public nuisance, shall be punished by a fine not exceeding $500 for each offense.

Comparison of these two acts shows a decided tendency toward more stringent prohibition against the pollution of the river. The only respect with which the statute of 1906 is less strict than that of 1902 is that the former statute omitted the prohibition of the discharge of substances which may obstruct the flow of the river, and limits the prohibition solely to substances which may be injurious to public health or may tend to create a public nuisance. It is important to note also that both statutes placed upon the State Board of Health the absolute responsibility for instituting proceedings for the enforcement of the acts through the attorney-general.

**Sewage Disposal.**—While much excrementitious matter formerly reached the river, none of the towns have recently had extensive systems of sewers which discharged into it. There were numerous privies along the banks, some private sewers and a few municipal drains which discharged into the river, and many mill closets were so placed as to utilize the stream.

Norwood, the largest of the towns, is provided with a sewage treatment plant. In the lower end of the valley the sewage is discharged into a Metropolitan sewer, which discharges into Boston Harbor. The small towns which do not have access to the Metropolitan sewer have as yet no sewer systems.

**Early Stages of Wastes Treatment Problem.**—The Neponset River has been utilized as a source of industrial water supply, for producing power and as a means of getting rid of liquid industrial wastes for many years. A tannery was established as early as 1776, to which the Winslow Bros. & Smith Co. is the present successor. In 1797 the antecedent of Bird & Son, paper mill, was established. Thus for considerably more than 100 years these establishments have made use of the waters of this river in the ways mentioned.

Changed conditions are due to two causes—an increase in the business done, resulting in the discharge of greater quantities of waste, and an increase in the population resident near the lower portion of the river.

At the time the prohibitory statutes were passed no effort was made to keep separate the sewage, trade wastes, condenser water, roof water, and other relatively clean waters. Each particular liquid was disposed of in the most convenient manner. The first step was, therefore, the construction of drainage systems to provide for the separation of some of the wastes which were previously combined, and to combine and convey to a pumping station or the treatment plant those which could be handled together economically. While this involved expense and presented difficult problems in many cases, it was by no means as difficult and perplexing as devising efficient practical processes of treatment. Wastes from different plants required entirely different means of treatment, and often different processes within the mill produced wastes of such widely dissimilar character that a single method of treatment would not serve both adequately. This condition led to many investigations and experiments. Large sums were, and are even now, being expended upon such work.

**Magnitude of Mill Owners' Problem.**—The problem created by the passage of the prohibitory statutes of 1902 and 1906 has proved to be of far greater magnitude than probably was anticipated at the outset by many of the interested parties. The size and importance of the general problem may be explained best by two illustrations from the experience of the writer's firm, which has served as consulting engineer in both cases.

The first problem presented was that of Bird & Son's paper mill at East Walpole. This mill is engaged in the manufacture of heavy papers, from hemp, cotton, burlap and old paper. A portion of the raw stock is boiled with strong alkali, washed and made into paper. There are three liquid wastes—the strongly alkaline boiler wastes, containing much dirt and vegetable matter; the washer wastes, which vary greatly from hour to hour, and which contain alkali, dirt and vegetable matter, and the machine wastes, which contain finely divided fiber which escapes from the paper machines. All of the wastes are somewhat colored and at times the washer and machine wastes are rather highly colored.

While the quantities of these wastes vary greatly from time to time, they average about as follows:

| | Gal. per day. |
|---|---|
| Boiler wastes | 10,000 |
| Washer wastes | 255,000 |
| Machine wastes | 3,200,000 |

A comparison of the quality of the paper mill wastes with that of some municipal sewages, may be made, with the results of analyses given in Table I. As would be expected, the nitrogenous compounds are rather low, although in the washer wastes the albuminoid ammonia is nearly as high as in the Brockton sewage, which is very strong. The carbonaceous matter, especially in the washer wastes, is high and the total and suspended solids are much higher than in ordinary municipal sewage.

It is illuminating to compute from these analyses and the quantities of the respective wastes, the approximate population or size of municipality from which equivalent quantities of similar substances would be produced and discharged as sewage. The results of such computations appear in Table II. Although there are relatively small quantities of organic nitrogenous compounds in these wastes, it is seen that, if measured by the albuminoid ammonia, they contain a quantity equivalent to the sewage from a city of nearly 20,000 inhabitants; the total and suspended solids are equivalent to the quantities produced by a city of nearly 100,000 persons.

At Winslow Bros. & Smith Co.'s tannery the wastes not only comprise the various wash waters and spent tan and dye liquors common to sheepskin tanneries, but also the scouring liquors and rinse water from the scouring of wool. The quantities of combined tannery and degreased scouring liquors and rinse waters are about as follows:

| | Gal. per day. |
|---|---|
| Combined wastes | 485,000 |
| Rinse waters | 225,000 |
| Total wastes | 710,000 |

TABLE I.—COMPARISON OF PAPER MILL WASTES WITH MUNICIPAL SEWAGES.
(Parts per million.)

| Nitrogen as: | Washer wastes * | Machine wastes.* | Worcester sewage.† | Chicago sewage.† | Brockton. sewage.† |
|---|---|---|---|---|---|
| Free ammonia | 1.78 | 0.53 | 20.3 | 8.8 | 61.2 |
| Albuminoid ammonia | 15.8 | 3.63 | 7.1 | ... | 22.1 |
| Oxygen consumed‡ | 480 | 158 | 193 | 19 | 247 |
| Residue on evaporation: | | | | | |
| Total | 3,908 | 1,188 | 882 | ..... | 1,584 |
| Suspended | 2,344 | 748 | 276 | 141 | 892 |

*Analysis by State Board of Health, Nov. 5, 1914.
‡Boiling 5 minutes.
†From "American Sewerage Practice," Vol. III, pp. 180 and 181.

TABLE II.—EQUIVALENT POPULATION TO PRODUCE SEWAGE CONTAINING SAME QUANTITIES OF THE SPECIFIED INGREDIENTS AS PAPER MILL WASTES—BROCKTON, MASS., SEWAGE TAKEN AS BASIS.

| Ingredients— | Population to produce sewage equivalent to— | | |
|---|---|---|---|
| Nitrogen as: | Washer wastes. | Machine wastes. | Washer and machine wastes. |
| Free ammonia | 200 | 800 | 1,000 |
| Albuminoid ammonia | 5,100 | 14,600 | 19,700 |
| Oxygen consumed | 14,200 | 58,300 | 72,500 |
| Residue on evaporation: | | | |
| Total | 17,900 | 68,300 | 86,200 |
| Suspended | 19,100 | 76,900 | 96,000 |

The composition of these wastes and the population which would produce an equivalent quantity of similar substances as sewage, are indicated in Table III.

It will be seen that these wastes are far stronger than the Brockton sewage in all determinations except free ammonia. It appears also that they are equivalent, so far as the analyses can indicate, to the sewage of a city of from 18,000 to 35,000 population.

From these comparisons of paper mill and tannery wastes with municipal sewage it is easy to understand the difficulties encountered and the burden of expense incurred by the manufacturers, in the treatment of their wastes.

TABLE III.—COMPARISON OF TANNERY WASTES WITH MUNICIPAL SEWAGE AND EQUIVALENT POPULATION TO PRODUCE SEWAGE CONTAINING SAME QUANTITIES OF SPECIFIED INGREDIENTS—BROCKTON SEWAGE TAKEN AS BASIS.

| Ingredients—<br>Nitrogen as: | Combined wastes, p.p.m. | Rinse waters, p.p.m. | Brockton sewage, p.p.m. | Equivalent population. |
|---|---|---|---|---|
| Free ammonia | 17.9 | 0.28 | 61.2 | 4,000 |
| Albuminoid ammonia | 29.3 | 1.5 | 22.1 | 18,300 |
| Oxygen consumed | 444 | 27.7 | 247 | 25,600 |
| Residue on evaporation: | | | | |
| Total | 3,915 | 190 | 1,584 | 34,900 |
| Suspended | 1,243 | 34 | 892 | 19,500 |

**Progress in Treatment of Trade Wastes.**—Much progress has been made in the diversion or treatment of the trade wastes. The State Department of Health reported that there are now (1916) about thirty mills discharging more or less wastes into the river. Some of "the wastes consist only of small quantities of acids and mineral salts, which have very little effect upon the stream."

Before the prohibitory statutes were passed, one wool scouring concern abandoned its location. Some manufacturers have diverted a portion of their business to other plants, and one has abandoned the manufacture of one line of goods, thus avoiding the production of a large quantity of liquid wastes which were very difficult to treat.

Eleven manufacturers have provided sedimentation tanks and ten have constructed strainers or filters of cinders, coke or sand. Some have adopted chemical precipitation as a means of improving upon the efficiency of natural sedimentation. Treatment plants have been provided in nearly all cases where the wastes require treatment. Some of them, however, are of insufficient size and others need additional equipment to carry the treatment further.

**Bird & Son's Treatment Plant.**—These wastes have been very carefully segregated into three classes, as already described. The boiler wastes are utilized for sprinkling streets, thus serving the double purpose of laying the dust and disposing of the wastes.

The washer wastes are pumped to four sedimentation tanks, having an aggregate storage capacity of 220,000 gal. The settled wastes then pass either directly to the river or to a dosing tank of 55,000 gal. capacity, from which they are periodically discharged on to filter beds constructed chiefly of coarse sand. There are 2.25 acres of filters which are capable of handling about 127,500 gal. per working day, of the settled wastes, except during the winter, when it has been found impracticable to prevent freezing, because the wastes are cold. In the winter the settled wastes are discharged into the river. During the remainder of the year the excess wastes above the capacity of the filters are discharged into the river. During warm weather and when the natural flow of the river is low, a definite measured quantity of water is drawn from storage, to provide as much dilution as the water resources will permit. Tests indicate that a dilution of 5 parts of river water to 1 of wastes has a stability of 7 days, and 10 parts to 1 has a stability of 11 days.

In a single year the settling solids removed from the washer wastes amount to about 6,700 cu. yd. of wet sludge, which is thus prevented from reaching the river. This sludge is drawn off on to sludge drying beds, from which it is taken in a semi-dry spadable condition and hauled to a dump. The 6,700 cu. yd. of wet sludge was reduced by drying, to about 1,960 cu. yd.

The effluent from the sand filters, when they are not overworked, is stable, free from objectionable odor, and suspended matter is practically absent, under the most favorable conditions.

The impracticability of operating the filters with the cold wastes in winter has led to prolonged studies to devise a method of treatment which will give a satisfactory effluent and will not be seriously affected by low temperature. The State Department of Health now has before it the recommendation based on these studies, and if it gives its approval, the present plant will be so amplified as to be able to produce a satisfactory effluent at all times.

The machine wastes are subject to a treatment entirely independent of that given the washer wastes. The former are treated with chemicals, pumped to settling tanks having an aggregate capacity of 860,000 gal. After a proper period of sedimentation the usually clear and practically colorless effluent is discharged into the river, without further treatment.

The quantity of suspended matter removed from the machine wastes is five times as great as that removed from the washer wastes. The machine wastes solids thus prevented from reaching the river are therefore equivalent to 33,500 cu. yd. of wet sludge, or 9,800 cu. yd. of dried sludge per year. The quantity of solids removed from both washer and machine wastes is therefore equivalent to 40,200 cu. yd. of wet sludge and 11,760 cu. yd. of dried sludge per year.

**Winslow Bros. & Smith Co. Treatment Plant.**—The wastes from the several processes in use at this tannery vary so greatly in quality that it has been deemed necessary to keep certain of them separate that each may be dealt with in the most practical manner. This necessitated a collecting system by which the wool-scouring liquors are conducted to the degreasing plant, the rinse waters from the wool-scouring department, after screening, are conveyed to Hawes Brook, a tributary of the river, and the wastes of the other processes combined and conveyed to the treatment plant.

The wool scouring liquors, after sedimentation, are treated for removal of grease by the acid-cracking process in common use for this purpose. The supernatant liquors drawn off from the acid-cracking tanks are conducted to the combined wastes channel and there mixed with the other wastes requiring treatment.

The combined wastes are brought together at one point, where they are passed through an inclined rack for the purpose of removing sticks and other coarse material which might injure the pumps. The screened wastes are then pumped to sedimentation tanks, through which they pass slowly, and in which the settling solids are retained. There are eight of these tanks, which have an aggregate working capacity of 900,000 gal.

Only three tanks are used for the sedimentation process. Two or three are used as required for the storage of night and holiday flows and the others are used for precipitation tanks when it is necessary to treat the settled wastes with chemicals.

The sedimentation process removes the settling solids, which constitute about 65 per cent of the total suspended matter. The wet sludge removed from the tanks amounts to about 6,300 cu. yd. per year, which indicates a part of what is being accomplished in the prevention of undue pollution of the river.

There are three other treatment processes utilized at this plant—intermittent filtration, dilution, and chemical precipitation. While all of the combined wastes pass through the settling tanks and are thus deprived of those suspended solids which might otherwise be deposited in the river, the other processes are used when practicable and as may be necessary to produce a character of water in Hawes Brook which shall not cause a nuisance after it reaches the river. In winter when temperatures are low and in spring when there is a high flow in the river, the tank effluent is discharged without further treatment. As soon as the river falls so as to provide inadequate dilution and the temperature becomes high enough to endanger the stability of the brook water, the filters are put into use.

There are 3.5 acres of sand filters. By most careful operation and frequent cleaning they are worked to the practical limit of their capacity from about June to November. Their capacity varies with different conditions, but ranges from 30,000 to 50,000 gal. per working day. The effluent, when the beds are operating normally, is clear, free from suspended matter, substantially odorless and well oxidized. Nitrification is good, for these wastes are high in organic nitrogen and encourage bacterial action.

During the early summer, while the temperature is moderate and there is a good flow in the river, that portion of the tank effluent which cannot be filtered is discharged into the brook without further treatment. The brook water, therefore, consists of the natural flow of surface water, the sand filter effluent, the comparatively clean rinse waters from the wool-scouring department and that portion of the tank effluent which cannot be filtered. The aim is to produce a water which, as it leaves Hawes Brook, will keep sufficiently long to avoid putrefaction before it reaches tidewater.

The "next line of defense" is dilution. A few years ago the company built a large storage reservoir which, together with other small reservoirs on Hawes Brook, has a storage capacity of about 800,000,000 gal. Suitable controlling and measuring works are provided, so that this water is drawn when the tank effluent is being discharged. The quantity drawn is in proportion to the quantity of wastes being discharged, and frequent tests and analyses are made to serve as a guide in determining the quantity of diluting water to be drawn.

The danger of long-continued drought makes it unwise to draw the water entirely out of the reservoirs, for the tannery is dependent upon them for water for steam and for technical purposes. Therefore, when the demand upon the supply becomes very large in hot weather and when the river discharge is at a minimum the settled wastes are treated by chemical precipitation. This not only reduces by 50 per cent the proportion of diluting water required, but it also increases the quantity of wastes the sand filters can handle successfully.

From this brief description it will be seen that great progress has been made in the treatment and that the treatment is carried out in an intelligent manner, with a regard for the laws of nature, with the exercise of care to avoid undue pollution of the river, and with a reasonable effort to utilize all available resources.

**Present Status of Wastes Treatment Problem.**—The State Department of Health has made analyses of samples of Neponset River water taken from June to November each year since 1886. These results, taken from a diagram in the report dated January 5, 1916, averaged by four and five-year periods, are given in Table IV. This table also contains factors obtained by multiplying the results of analyses in parts-per-million by the flow in gallons-per-day per square mile of drainage area.

These analyses show that there was a gradual increase in the pollution of the river water, as indicated by the free and albuminoid ammonia determinations each five years until the end of 1910. There has been a very marked decrease during the last five years, in spite of low rates of river discharge. This comparison, however, does not indicate all of the improvement which has been accomplished, because it takes no account of the total quantity of polluting substances in the river. This is indicated by the factors. From these it will be seen that the pollution as indicated by the free ammonia has been less during the last five years than during either of the two preceding similar periods. The albuminoid ammonia indicates less pollution during the last period than in any other except that ending in 1895, and 55 per cent less than that of the period ending in 1905.

TABLE IV.—COMPOSITION OF NEPONSET RIVER WATER.
1887-1915.

| Period. | Free ammonia, p.p.m. | Free ammonia *factor. | Albuminoid ammonia, p.p.m. | Albuminoid ammonia *factor. |
|---|---|---|---|---|
| 1887-1890........ | 0.7 | 0.597 | 3.9 | 3.142 |
| 1891-1895........ | 2.3 | 1.101 | 3.9 | 1.330 |
| 1896-1900........ | 3.7 | 0.751 | 5.9 | 2.333 |
| 1901-1905........ | 4.6 | 1.939 | 8.7 | 3.816 |
| 1906-1910........ | 11.8 | 2.582 | 12.0 | 3.124 |
| 1910-1915........ | 8.1 | 1.795 | 9.0 | 1.719 |

*Parts per million x gallons river discharge per square mile per day.

In spite of this improvement, bills are annually introduced in the Legislature, aiming at more stringent regulations and more rigid enforcement of the prohibitory statutes. At the outset of the agitation the protection of the public health appeared to be the predominating concern of those striving for legislation. Recently other standards appear to be increasingly considered, as indicated by the following quotation from a proposed but defeated bill of 1915:

> A river shall be held to be polluted within the meaning of this act whenever by the introduction or discharge into its water of any foreign or deleterious substance: (a) it shall give out any noxious or offensive smell, odor or vapor, which condition is a menace to the public health; (b) it shall become discolored in such a way as to be unsightly or offensive, or (c) it shall become poisonous or dangerous to fish or animal life subsisting therein, or to livestock using the same as a drinking place; (d) it shall become injurious to vegetation in its vicinity. (Mass. Senate Bill 77, 1915, Sec. 2.)

That existing wastes treatment plants must and ought to be amplified in some instances is conceded by the manufacturers, and projects are now under way which will increase greatly the efficiency of wastes treatment. The expenditure already made in the construction of wastes treatment plants probably approaches $500,000, and with such additions as are contemplated will certainly substantially exceed this sum. A comparison of this expenditure with that of $202,000 by the State and benefited land owners, upon the drainage of the Fowl Meadows and improvement of the river channel, is not without significance. But the capital expenditure is not the heaviest burden—the fixed and operating charges probably now exceed $50,000 per year, and they may run to $100,000 within a very short time.

The work thus far done demonstrates that the industrial wastes can be so treated as to prevent the creation of deposits in the river and the evolution of the inherent odors of trade wastes or offensive odors due to putrefaction. But how much more exacting the requirements will be made by future legislation is not yet demonstrated. It is to be hoped that they will not be made so drastic that the industries will be driven to other less restricted localities. A reasonable use of the river by manufacturers should not conflict with a reasonable enjoyment of it by the citizens of the towns through which it flows and may result in the greatest good to all concerned.

## REMOVING SUBMERGED PIPE LINES BY DERRICK.

Two 24-in. flexible joint pipe lines under Chelsea Creek between Chelsea and East Boston, Mass., were successfully removed in 1915 by lifting them in sections by derrick. The old pipe lines, which were buried about 5 ft. below the bottom of the channel, were removed without excavating a trench, by pulling them up in sections with a large wrecking lighter equipped with a derrick having a boom 95 ft. in length. The sections usually included two or three pipes but on one occasion seven pipes were pulled up at one lift. The derrick sling was placed around the pipes by a diver who made the necessary excavation for this purpose with a jet of water supplied from a pump on the lighter.

## PERSONALS.

Jerome Summerfield has been promoted from pitometer operator to assistant engineer of the Water Board of Baltimore, Md.

F. H. Volks, assistant engineer of construction of the Water Department, Cleveland, O., was killed in a tunnel accident on July 24.

C. Boone Sadler, 907 North Arlington avenue, Baltimore, Md., has been appointed pitometer engineer of the water department of that city.

S. T. DeLaMater, consulting engineer, Chicago, has been elected president of the Chicago General Construction Co., with offices in the Manhattan building, Chicago, Ill. Mr. DeLaMater was previously associated with Graham, Burnham & Co., James Stewart & Co., L. P. & J. H. Smith and other well-known engineering construction companies.

Wm. G. Sloan, chief engineer of MacArthur Bros. Co., New York City and Chicago, has been elected vice-president to succeed F. C. Hitchcock.

John H. Chidester, 3441 Queen Lane, Philadelphia, has been appointed chief steel inspector for the Department of City Transit of Philadelphia.

William A. Schell, Charlotte, N. C., has become connected with the Jacksonville Engineering & Construction Co. of Jacksonville, Fla., and has removed to that city.

S. M. Bate has been appointed engineer of the Kansas City Stock Yards Co. of Kansas City, Mo., succeeding Henry A. Wise, for the past twenty years engineer of the company.

R. W. Sharp, for several years superintendent of the filter plants and city bacteriologist of Rock Island, Ill., has re-entered the employment of the Pitsburgh Filter Mfg. Co., of Pittsburgh, Pa.

John L. Mange has been elected vice-president of the J. G. White Management Corporation of New York City. Mr. Mange has been associated with the White Management Corporation since 1912.

Earl McIntire, for the past seventeen years connected with the engineering department of the Youngstown works of the Republic Iron & Steel Co., has been appointed field engineer for the Canadian Steel Corporation of Ojibway, Ontario.

Howard W. Morgan, formerly senior engineer with the Sewerage Commission of Milwaukee, Wis., has become associated with the Dorr Company, engineers, 17 Battery place, New York City, and will specialize in sewage disposal problems.

F. C. Hitchcock has resigned as vice-president and general manager of McArthur Bros. Co., New York and Chicago, and has become vice-president and general manager of the Siems-Carey Railway & Canal Co., which will undertake extensive construction work in China.

L. J. Charles, construction engineer of the Elephant Butte project of the U. S. Reclamation Service, has been appointed to a position in the State Engineer's office of New Mexico and will have charge of hydrographic work and stream gaging He succeeds S. S. Carroll, who resigned to become resident engineer of the Sanguijuela project, near Las Vegas, New Mexico.

The Siems-Carey Railway & Canal Co. has taken out a Delaware charter with a capital stock of $500,000. The company proposes to construct canals and waterways. The incorporators include C. L. Rimlinger, Norman P. Coffin and Clement M. Egner. These same incorporators also have taken out a charter for the China Corporation, which will enter into contracts with builders and contractors, etc.

William W. Ewing has been selected by the Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce to conduct an investigation covering all the southern republics regarding a market for construction materials and machinery in South America. Mr. Ewing will spend the next three months visiting the principal cities of the United States and conferring with manufacturers with regard to the work he will do in South America. Conferences with him may be arranged and suggestions are invited. Correspondence is to be directed to Division of Commercial Agents, Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, D. C. Mr. Ewing has had twenty-seven years' experience in engineering and construction work, four of which were spent in foreign countries. He is a member of the American Society of Civil Engineers and the American Society of Testing Materials. He was chief engineer for the Compania General de Asfatos y Portland, Barcelona, Spain; engineer of tests in New York Department of Buildings for six years, and has been engineer in charge for a number of years for some of the largest international engineering and construction and equipment companies.

## OBITUARY.

Henry J. Spieker, president of the Henry J. Spieker Co., general contractors, of Toledo, O., died suddenly July 31, as the result of heat prostration.

James A. McIntosh, the last surviving member of the McIntosh Brothers Co., railway contractors, died July 28 at his home, 20 Prospect avenue, Milwaukee, Wis. Mr. McIntosh was born in 1845 at Glengarry, Ontario. He entered into the contracting business in 1862 with his brother, the late Donald A. McIntosh. Their most notable construction underttaking was the building of 800 miles of the Chicago, Milwaukee & Puget Sound Railway, the new Pacific Coast extension of the Milwaukee.

## NEW CATALOGS.

**Pumps.**—Paper; 8 in. x 11 in., 24 pp. Dayton-Dick Co., Quincy, Ill.

This consists of two bulletins. Bulletin No. 13 illustrates and describes the Hayton High Grade Centrifugal Pumps, Type C. S., and Bulletin No. 12 is given up to the Hayton Type M. Centrifugal Pump. Complete descriptions of these pumps, including tables of size and capacity and speed range and power, are given.

**Motor Trucks.**—Paper; 5 in. x 8 in., 40 pp. Pierce-Arrow Motor Car Co., Buffalo, N. Y.

The title, "What Pierce-Arrow Motor Trucks Are Doing in the Contracting Business," explains the purpose of this booklet. It contains a considerable amount of information on the use of trucks for various classes of construction.

**Water Works Brass Goods.**—Paper; 7½ in. x 10½ in., 72 pp. United Brass Manufacturing Co., Cleveland, O.

This is Catalog D-1, compiled expressly for water works. It is the forerunner of a general catalog, now in preparation, which will show the complete "United" line of brass goods. The catalog contains several tables of technical matter especially selected because of their practical application of water works problems. One of the tables, giving the proportionate delivery of all pipes from ⅛ in. to 10 in., is original and was calculated for this book by Fred Schulder, head of the architects' service department.

## INDUSTRIAL NOTES.

Wallace & Tiernan Co., Inc., manufacturers of Chlorine Control Apparatus, has opened its new factory at 137 Center St., New York City, where the company will have over three times its former floor space and much better facilities.

A. C. Garrison has been elected president of the Corrugated Bar Co., succeeding his father, D. E. Garrison, who died early in July. A. L. Johnson became vice-president and general manager and W. H. Kennedy vice-president and treasurer.

The Shawmut Paving Brick Works, of Shawmut, Pa., and The Pennsylvania Clay Co., Pittsburgh, Pa., have become licensees of the Dunn Wire-Cut Lug Brick Co. The Shawmut company has an approximate daily capacity of 30,000 paving brick, but the company is contemplating the enlargement of the plant to a 50,000 daily capacity. The Pennsylvania Clay Co. has one plant at Conway, Pa., with a capacity of 60,000; one plant at Crows Run, Pa., with a capacity of 60,000; and one plant at Bradys Run, Pa., with a capacity of 40,000. The acquisition of these two companies gives the Dunn Wire-Cut Lug Brick Company 32 licenses, operating 52 plants.

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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## TRENCH BACKFILLING MACHINES.

Ten years ago it required insistance to make the ordinary trenching contractor listen to any plan for using mechanical trench excavators. Today no trench is too small and only a few are too large to be dug with trench excavators and the contractor is rare who has much trenching to do and does not do it largely by machinery. The salesman's task of the trench excavator manufacturer is not now the task of convincing contractors that trenching by pick and shovel is comparatively uneconomical, but the task of inducing choice of his particular excavator instead of the excavator of one of a number of other manufacturers. With time and competition the trench excavator has become a remarkably efficient and versatile machine. In its largest sizes it weighs over 50 tons and will excavate trenches nearly 30 ft. deep and 7 ft. wide; with its smallest sizes, trenches as narrow as 12 in. and as shallow as 3 ft. may be dug. A moment's retrospection makes these statements impressive.

Trenching is a double task of earth moving—backfilling in almost all work of trenching succeeds excavation. The two processes, excavation and backfilling, are co-ordinate processes of a single operation. In the earlier days of trench excavation development, the designers and builders of trench excavators dreamed frequently of a combination device which would accomplish these co-ordinate tasks. Some of these visions materialized. One materialization which the editor remembers particularly well consisted of a long carriage extending back from the excavator along the side of the trench. This carriage supported a belt conveyor and its ordinary appurtenances. Spoil from the excavator dropped onto the conveyor belt and was thereby transported to the rear and shunted back into the trench. The arrangement was successfully mechanically, but it was tremendously cumbersome. Appalling to the contractor as was the idea of a 75-ft. train of mechanism for digging a trench, there was a greater real obstacle to the popularizing of the combination. Its success depended upon a co-ordination of speeds, excavating, pipe laying and backfilling, so precise as to be impracticable. At least contractors considered such precision impracticable and they would have nothing to do with the "contraption."

There remained, however, in trenching the incongruity of excavating with a highly specialized and economical mechanical device and then filling back the excavated material by hand. The team and slip scraper advanced efficiency but did not fully meet the demands. It was the commercialization of the drag line bucket excavator that finally established the trench backfilling machine as a practicable device. The builder of trenching machinery produced a drag line bucket excavator in miniature and had a trench backfilling machine. Its appeal to trenching contractors has been large and their favor has been deserved, and is deserved for other reasons than that trench backfilling has been speeded up and reduced in cost. In the standard types of drag line scraper backfillers the trenching contractor has a small traveling power plant which he can put to a number of uses. He can pull trench sheeting with it as illustrated in one place in this issue, or operate with it a derrick as described in another place, and he can use it for many miscellaneous tasks of hoisting and hauling ordinarily performed in trenching by less effective means because not common enough to warrant provision of special plant for their performance.

## INEXCUSABLE IGNORANCE ABOUT RAILWAY TRANSPORTATION COSTS AND RATES.

Commenting upon the suit brought by New Jersey to compel railways to charge a lower freight rate to New Jersey terminals than to New York City, "Engineering News" displays an ignorance of railway transportation costs that is peculiarly surprising. We read, for example, that in hauling freight between Philadelphia and New York:

"The total terminal expenses at the two ends of the route were found to be $3.65, whereas the total cost of hauling a ton of freight over the 90 miles of railway between the two cities after it was once started on its journey was only 27 ct."

If true this would be the most amazing revelation of railway inefficiency that was ever published, for it would mean that the total cost of transporting a ton of freight from a Philadelphia dealer to a New York dealer is $3.92, or more than 4 ct. per ton-mile! A brief analysis of this so-called "cost" is illuminating. "Engineering News" gives its details as follows:

| | Per ton. |
|---|---|
| Loading on track at Philadelphia | $0.25 |
| Hauling to station and unloading | 0.50 |
| Weighing, billing and clerical | 0.40 |
| Switching at Philadelphia | 0.25 |
| Terminal costs at New Jersey side of Hudson River | 0.15 |
| Lighterage across Hudson River | 0.80 |
| Terminal cost on New York water front | 0.50 |
| Loading and trucking in New York | 0.80 |
| Total | $3.65 |

Note particularly that interest charges on the terminal plant at Philadelphia have been overlooked. Note also that the 27 ct. estimated cost of hauling a ton 90 miles is based on an assumed 0.3 ct. per ton-mile cost, which is said to include interest charges on the roadbed and rolling stock. But, above all, note that every one of these alleged costs is a pure guess. It is true that for the last four items of the $3.65, "Engineering News" quotes an "estimate" made by Mr. Wm. J. Wilgus, but that also is a guess.

When engineers are not guessing on important matters of this sort it is customary to cite supporting data based on actual records. Where are the data? Who knows what it costs to load and haul the average ton of freight from the shipper in Philadelphia to the Philadelphia railway station? Where are the data to support the guess of 40 ct. per ton for weighing and clerical expense? As a matter of fact, 40 ct. multiplied by the number of tons of freight shipped annually over all railways gives a total that would almost pay the annual salaries and wages of half the railway employes in America! Likewise a switching cost of 25 ct. per ton multiplied by the total annual tonnage of American railways would pay the salaries of all the enginemen and firemen twice over! To dignify such figuring by the term of "estimating" is to make engineering cost estimates a byword.

Based on these wild guesses, "Engineering News" proceeds to prove that "it costs the railways about as much to handle this freight in the terminals at each end [Chicago and New York] as it does to haul it the entire thousand miles between the two cities." We need scarcely add that no such relation of costs is even remotely correct. Yet it seems desirable to say so, because of the tendency of ill-informed people to seize upon apparently authoritative statements to bolster up claims for a grand readjustment of freight rates. Indeed, "Engineering News" itself goes so far as to support the contention of New Jersey that residents of New Jersey are being grossly discriminated against, for the "News" says:

"It follows that the merchants and manufacturers of Jersey City, Hoboken and Newark are actually paying in their freight rates part of the cost of carying goods for their competitors, located on the eastern side of the Hudson River."

To read such charges of unfairness with a straight face is difficult, for, if they were true, it would amount to accusing railway managers of being wholly devoid of common sense. Here, according to the complainants, are the railways expending $1 or so to haul every ton across the Hudson River when the railways might save it by giving a lower rate to shippers on the west bank of the Hudson. To do so, it is aleged, would cause freight to stop on the west bank in New Jersey. To put it thus is to charge the railways with being in league against their own best interests, yet that is precisely what they are charged with by the instigators of this New Jersey suit and by "Engineering News."

What the New Jersey residents and "Engineering News" fail to grasp is the fact that the vast bulk of freight moves to New York City because it is used there by manufacturers, shippers and consumers, and not because of a discrimination in rates. They fail also to know that the cost of lighterage across the Hudson is an insignificant item of cost, as will be proved when the hearings before the Interstate Commerce Commission take place. But above all, they fail to realize that the transportation costs of a railway vary almost inversely as the density of traffic, and that consequently every keen railway manager seeks to increase the density of traffic by giving rates that will assist in building up those terminals that—taking every commercial factor into consideration—are best able to develop a large business. The island of Manhattan is one of those favored spots that it pays the railways to foster.

We doubt not that it can be demonstrated that if one railway were built from Chicago to New Jersey terminals and another from Chicago to New York City, each independent of the other and each giving rates that would yield a fair return on their respective investments, the railway to New York would be able to quote a much lower rate from Chicago than could be quoted by the other railway for haulage from Chicago to New Jersey terminals. The difference in density of traffic on the two lines would be so greatly in favor of the line to New York City that all questions of difference in cost of lightering or tunnel haulage across the Hudson would merge into insignificance. This being so, it follows that, instead of complaining because they have not a lower rate than has New York City, the cities of New Jersey should rejoice because they do not have a higher rate, which, if left to themselves, they would assuredly have.

When it comes to scientific prorating of joint costs, as we have shown in previous articles in these columns, it is essential to apply "the separate plant theory"—that is, to estimate the cost of each class of service on the basis of the most economical plant designed to render that service only, and to prorate the joint cost in proportion to the separate costs thus estimated. On that basis it will be found that many a small user of a common or joint plant is actually receiving too low a rate to be equitable, compared with the larger users of the plant.

If New Jersey chooses to class its industries together and fight for lower rates than New York City now enjoys, New Jersey will discover that equitable prorating of the "joint costs" of railway transportation will result in higher rates for New Jersey and lower rates for New York City.

This case bids fair to be a more important struggle than the famous "Spokane rate case" of ten years ago. The editor was one of the engineering witnesses in that case and now recalls the question that then rose in his mind: If American cities or states begin earnestly battling with one another for preferences as to railway rates, when will the struggle end, and what will it ultimately lead to?

The theory that specific rates should be based on the specific costs incurred sounds simple, but it leads to complexities that are distracting enough to the most expert student of economic problems, and wholly beyond the understanding of all others. Yet "Engineering News" naively says:

"Nothing can be clearer to traffic experts than that the present plan of practically ignoring cost of service in fixing rates is pernicious in principle and distributes the transportation tax most unfairly."

If there is one thing that "traffic experts" do agree upon, it is that specific railway rates should not be based on the specific costs of the service rendered, even were such costs ascertainable.

## COST OF MOVING A STEAM SHOVEL WITH A MOTOR TRUCK CONTRASTED WITH SELF-MOVING.

A 60-ton Marion shovel was recently dismantled and reassembled at a cost of about $300. It was hauled in 9 loads by a 5-ton Locomobile truck a distance of 32 miles at a cost of about $500, including $50 labor loading and unloading, in addition to the time of the truck driver and helper. The motor truck drew a trailer. The heaviest single load was 10.5 tons.

In moving a 60-ton shovel by its own power over country roads, the speed varies from about one-quarter mile per day, where there are a good many steep grades, to one-half mile per day where the road is comparatively level. The cost is seldom less than $40 a day for the gang and fuel, and is therefore rarely much less than $100 per mile moved over fairly level roads.

From the foregoing data it would seem that to a fixed cost of about $400 for dismantling, loading, unloading and reassembling a 60-ton shovel, there should be added about $16 per mile for hauling it with a motor truck and trailer, provided the roads are fairly good. At this rate, if the haul is more than about five miles, it will pay to use this method rather than move the shovel with its own power.

Where a shovel has to be moved up grades so steep that it can not use its own traction, but must employ blocks and tackle, the cost of moving becomes very high. For a 60-ton shovel this sort of moving may cost $2,000 per mile.

The cost of moving heavy shovels is high at best, so that any improved method, such as that by motor truck and trailer, is decidedly welcome.

## SOME NOVEL USES OF AUTOMOBILE ENGINES ON CONSTRUCTION WORK.

Within the month we have seen photographs of old automobile engines made to do four kinds of service for which they were not originally designed. The four services were: (1) Running a small dynamo that operated wood boring tools. (2) Operating a centrifugal pump for testing water mains. (3) Operating an air compressor furnishing air to a hammer drill. (4) Drawing a train of small dump cars.

In each case, except the last named, the automobile engine was also used to drive the automobile, and upon the chassis was mounted the electric generator, or the air compressor, or the centrifugal pump.

In the fourth case an old Ford engine was mounted on the trucks of a Koppel dump car, and the power was transmitted from the engine, by a chain drive, to a cross drive shaft provided with a gear shift that made it feasible to run the "locomotive" backward as well as forward on "high." The "locomotive" was geared to travel at about 7 miles an hour on "high."

By substituting light railway car wheels for the ordinary automobile wheels, old "pleasure cars" are often converted into work cars and used for various purposes on railways, which reminds us of a recent photograph of a motor truck converted temporarily into a railway car for use by our troops in Mexico. In that case the wheels were equipped with detachable flanged steel rims fitted over the ordinary truck wheels. The steel flanges could be speedily removed when the truck had to travel on dirt roads. This is a "trick" that contractors will do well to bear in mind.

Electric motors are often very economic for operating small rotary tools, like augers, wrenches, pipe threaders, pipe couplers, etc. But ordinarily a contractor has no electric current available. A small dynamo, mounted on the rear of a "pleasure auto" can be driven from the engine shaft of the automobile. Half a dozen wood augers have thus been operated simultaneously from such a portable plant.

There are literally thousands of second-hand pleasure cars that can be bought for $300 or less, and converted into very useful machines in ways such as above indicated. In these days of high-priced and scarce labor, it behooves every contractor to put his wits to work more than ever.

### LIFE OF BELT CONVEYORS.

An unusually long life of rubber belts for conveying ore is recorded in the Bulletin of the Am. Inst. of Mining Engineers for August. Mr. Hugh Rose states that at the Santa Gertrude's mine in Mexico one of the belts was not replaced until it had transported 1,131,708 tons. Another belt installed in June, 1911, "has handled 691,999 tons of ore and from all appearances is good for a repetition of this duty." These belts are 8/6 ply R. C., 30 in. wide, operated at 200 ft. per minute. The long life of the belts is attributed in part to the fact that the ore contains an unusually large percentage of fines which reaches the belt first and forms a cushion or bed for the larger rocks.

### THIRTY-ONE THOUSAND ENGINEERING STUDENTS IN 1911 AND ONE HUNDRED AND TWENTY THOUSAND ENGINEERS IN 1910.

Statistics published at the annual convention of the Society for the Promotion of Engineering Education show that in 1915 there were 32,843 engineering students enrolled in the engineering schools and colleges of America. Of these 7,182 were students of civil engineering, which was 800 fewer than in 1906. Students of mining engineering decreased even more markedly.

The following table gives the number of each class of engineering students in 1906, 1911 and 1915:

| | 1906. | 1911. | 1915. |
|---|---|---|---|
| General | 2,501 | 5,591 | 6,059 |
| Chemical | 1,234 | 1,452 | 2,383 |
| Civil | 7,962 | 8,934 | 7,182 |
| Electrical | 5,696 | 6,128 | 6,637 |
| Mechanical | 7,426 | 7,052 | 7,751 |
| Mining | 2,826 | 2,337 | 1,922 |
| Other | 82 | ..... | 958 |
| Total | 27,727 | 31,499 | 32,843 |

In 1912, according to the Report of the Commissioners of Education, the undergraduate engineering students numbered 18,859, distributed as follows:

| | |
|---|---|
| Chemical | 725 |
| Civil | 5,278 |
| Electrical | 3,652 |
| Mechanical | 6,800 |
| Mining | 2,244 |
| Textile | 133 |
| Sanitary | 27 |
| Total | 18,859 |

According to the U. S. census for 1900 there were the following numbers of practicing engineers, etc.:

| | |
|---|---|
| Civil engineers | 20,153 |
| Surveyors | 6,034 |
| Designers, draftsmen and inventors | 18,956 |
| Mechanical and electrical engineers | 14,440 |
| Mining engineers | 2,904 |
| Chemists, assayers and metallurgists | 8,887 |
| Architects | 10,604 |
| Total | 81,978 |

According to the U. S. census for 1910 the corresponding numbers were as follows:

| | |
|---|---|
| Civil engineers and surveyors | 52,033 |
| Designers | 11,788 |
| Draftsmen | 33,314 |
| Inventors | 2,347 |
| Mechanical engineers | 14,514 |
| Electrical engineers not given separately, but classed with electricians, totaling 135,519. | |
| Mining engineers | 6,930 |
| Chemists, assayers and metallurgists | 16,273 |
| Architects | 16,613 |
| Total (excluding about 15,000 electrical engineers) | 153,812 |

It is evident that the number of civil engineers and surveyors doubled in ten years, and that, excepting architects, each of the above listed classes has also doubled. It is probable that of the 135,519 "electricians and electrical engineers," about 15,000 are electric engineers. This would give a grand total of about 169,000 engineers, surveyors, draftsmen and architects in America in 1910.

Excluding all architects and inventors, and excluding half the designers, draftsmen and chemists, the remainder is about 120,000, who may be broadly classed as engineers. This is about four times the number of students in the engineering schools and colleges in 1910.

The writer, while on the editorial staff of "Engineering News," wrote an editorial that was published in that journal June 1, 1905, in which statistics similar to the above were given and inferences drawn as to their significance. It was pointed out that the large number of engineering students must inevitably lead to severe competition for the purely professional positions, and that most of the students should be trained for executive or business positions in which their engineering knowledge could be used to advantage. The writer said:

"A text book on law and another on cost keeping and the management of men should form part of every engineering student's library."

That editorial, now eleven years old, was perhaps the opening gun of the campaign of publicity that has led so many engineers to enlarge their conception of what constitutes engineering. Six months later, in 1906, when the writer began his editorial work on Engineering and Contracting, this publicity campaign was pushed earnestly, and from that day to this there has been no let up in our editorial policy of urging engineers to push into business, manufacturing, transportation and political positions. We have held that there is a vast and fertile field for graduate engineers who combine a knowledge of management with a knowledge of engineering. Nearly every engineering periodical and many an engineering society has joined us in this propaganda.

It remains now to teach the general public that the modern engineer is more than a professional man. The engineering colleges will do well to assist in giving publicity to this fact, for the falling off in the registration of engineering students is due primarily to a popular feeling that the engineering field is becoming crowded. Pure "professional engineering" is crowded, but "managerial engineering" will never be crowded within the lifetime of any man who now reads these words.

### THE EDITORIAL WISEACRE.

One of the interesting products of modern newspapers is the omniscient editor who essays to solve the most difficult economic problem at one sitting. In a twinkling he writes the editorial answer to any question, and proves how speedily genius can come to a conclusion upon which mere mediocrity plods for months or years.

By deft guessing as to costs and daft cogitating as to principles, it is possible to build in an hour as seemingly logical a structure as the most painstaking technical expert can rear in years. Therefore, all hail the cocksure editorial genius, for this is the day of his popularity. Tomorrow he and his works vanish, so give him solemn attention while he still is with us.

### GERMAN AND AMERICAN FREIGHT RATES COMPARED.

To compare the average freight rates per ton-mile of two different American railways is difficult, partly because of differences in traffic density, partly because of differences in construction costs, partly because of differences in average length of haul. It becomes even more difficult where American railway rates are compared with those in foreign countries. This is exceedingly unfortunate, for rough calculations indicate that American rates average much lower than European rates for similar service, in spite of the fact that the average American railway employe receives a wage more than double that of the average European railway employe.

Mr. H. W. Faus, in an article in the "Railway Age Gazette" entitled "Where German Efficiency Falls Down," points out that the average freight rate in Germany 1.37 ct. per ton-mile for an average haul of 62 miles, as compared with 0.73 ct. in America for an average haul of 149 miles, in spite of the fact that Germany has a population 4.5 times as dense per mile of railway as ours. He argues correctly that the short average haul is a minor factor in causing the high freight rates of Germany. Illustrative of this he compares two groups of American railways, Group III (Ohio, etc.), having an average rate of 0.58 ct. per ton-mile for an average haul of 125 miles, and Group VII (Montana, etc.), having a rate of 0.9 ct. for a haul of 235 miles, or nearly twice as long.

This comparison of average rates and hauls in these two groups shows that long haulage is of minor importance, as compared with density of traffic, in securing a low freight rate per ton-mile.

## THE AFFILIATION OF LOCAL ENGINEERING SOCIETIES.

A noteworthy step toward general engineering co-operation is the organization of the Minnesota Joint Engineering Board. The societies represented on the Board are the Northwestern Association of Members of the American Society of Civil Engineers, the Minnesota Surveyors' and Engineers' Society, the Civil Engineers' Society of St. Paul, the Engineers' Club of Minneapolis and the Minnesota sections of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers. Mr. George W. Pathjens of St. Paul has been chosen secretary.

The primary object of this Board is to accomplish more for the public welfare than has been possible without joint action on the part of the engineers of Minnesota.

Our older readers will remember that we have often urged just such action as this, believing that both the interests of the general public and the interests of engineers as engineers demand the co-operative action of all engineers in respect to public matters upon which engineers are most competent to pass judgment. By taking active part in forming public opinion, in educating the editors of daily papers, in showing what engineers are capable of accomplishing and in exposing the wastes of incompetent political officials, engineers will greatly accelerate the public efficiency movement.

It is only a straw whirled in advance of the gale, but a significant straw, that the names of two celebrated engineers have been recently mentioned as "dark horse" presidential possibilities. We refer to Goethals and Hammond. John Hays Hammond, mining engineer, has been suggested in previous years as a vice-presidential nominee of the Republican party. This year he has been spoken of as a possible candidate for the presidency.

It is not beyond the bounds of possibility that within the next eight years some great executive engineer may become the President of the United States. Surely the training and experience of such a man as Hammond or Goethals is more likely to develop a better head for the federal government than is ordinarily securable through experience as a lawyer or judge.

The public as yet has but a vague conception of what qualities, education and experience are most essential in developing executive powers. To be a good "speechifier" is still the greatest single asset of a man who aspires to political office through election. But this will not always remain the chief criterion of "availability" for office. In time the public will learn that mayors, governors and presidents should be men trained in economics rather than rhetoric. It will then be more apparent that engineering, which is applied economics, serves admirably to develop an efficient manager of public affairs, provided, of course, that the engineer possesses native ability of the executive order.

We hope to see the engineers of every state take action similar to that just taken by the engineers of Minnesota.

## "MILITARY PREPAREDNESS."*

The military appraiser of America's resources for war turns an appreciative eye upon the contractor, the contractor's foreman and the men who do his bidding in field and camp. The contractor is a trained builder—often today he is a technically educated builder. He is always used to outdoor work, he knows how to handle men, he knows the tools of construction, he has initiative and resource, and, more than all these, he possesses an alert appreciation of the value of speed in construction. The contractor's foreman is the contractor's troop commander. The men of his gang are trained workers with tools, are innured to exposure, are used to danger, are accustomed to co-operative effort. It is invidious, perhaps, to make comparisons, but, taking him by and for the construction gang, "husky" is a fighting man with few equals in courage and endurance. Few pursuits of peace train men so well for modern warfare as does engineering construction. And of all contractors and contractors' men none ranks higher in possessing the rough and ready accomplishments required by the engineer corps of an army in the field than does the excavation contractor and his men. So no issue of this journal can more appropriately contain mention of two recent books on the tasks of the engineer in war than this issue, devoted to the problems of the earth mover and the rock man.

The most part of military operations in the field is engineering. Transportation, including bridge and road and railway building, as well as vehicular means for carriage, is the greatest part. Next comes the field fortification earthwork, the trenching, tunneling and mining operations of the battle line. Third is demolition, destruction of means of transportation and sources of supplies to delay a pursuing army. These do not include all the works of the engineer in the field. Reconnoissance and mapping are others. Gunnery is engineering, and so are aeronautics. But gunnery and aeronautics are specialists' tasks and mapping is, or should be, a task preceding military operations instead of one of these operations. For the general engineering tasks of the army in the field, transportation, field fortification and demolition, the men of the engineering construction field possess remarkable fitness. The two books being considered present noteworthy evidence toward this conclusion.

Engineering construction preceding, at and behind the line of battle is in sharp contrast in most respects to engineering in times of peace. The works are temporary, appearance cuts no figure providing serviceability is ensured, cost is a negligible factor, but speed of construction with makeshift materials and simple tools is vital. The engineering that service with the mobile army calls for is the kind that confronts the contractor who sees the water threatening to overtop his partially finished dam, that the railway engineer has to perform when a washed-out trestle is holding up traffic, that the Mississippi levee guard must accomplish when floods break the barrier he has erected against them. The outstanding feature of Major Pond's book is the circumstance and insistence with which it presents the special nature of the work and the special qualifications to perform it which characterize military engineering. This statement indicates the distinction between the two works being discussed.

"The Engineer in War" is a discussion and explanation of general principles of military field engineering; "Military Preparedness and the Engineer" is a manual on the technique of military engineering organization and of field fortification, mapping and bridge building for mobile troops. To a very considerable degree the two books supplement each other. An abbreviated schedule of the chapter titles of the two books illustrates this fact most clearly. For his subjects Major Pond selects: Military Policy of the United States; General Duties and Economics of Military Engineering; Tools and Equipment; Stream Crossings; Military Roads; Field Fortifications and Siege Operations; Demolitions; Reconnoissance, Sketching and Surveying; Sanitation; Mobilization of Material Resources; How May Engineers and Contractors Prepare to Meet Military Obligations of Citizenship? Captain Robinson's subjects are: How to Obtain a Military Training; The National Guard; Military Organization and Administration; Tactics of Engineer Troops; Fire Action; Field Fortifications; Obstacles; Siege Works; Demolitions; Bridges; Sketching; Needs of Engineers in War. Both works give lists of treatises and articles for supplementary reading.

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*"The Engineer in War."—By P. S. Bond, Major, Corps of Engineers, U. S. A. McGraw-Hill Book Co., New York. Leather; 5x7 in.; pp. 187; illustrated. $1.50.

*"Military Preparedness and the Engineer."—By E. R. Robinson, Captain, Corps of Engineers, N. G. N. Y. Clark Book Co., New York. Leather; 4¼x6½ in.; pp. 224; illustrated. $1.50.

These two little volumes deserve to be studied by construction engineers and contractors for several reasons. They give insight into matters concerning which the engineer and contractor as a citizen should be informed. They give information of emergency construction methods and devices which in many instances are applicable to civil works of construction. And, not least, they give the engineer and contractor the feeling of satisfaction that few citizens of a citizenry untrained to meet war have greater possessions ready for immediate service when war arrives.

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## ROTATED SPECIALIZATION COMMENDED..

To the Editor: Permit me to congratulate you on your new venture in producing your "Excavating and Railways" issue.

After having plowed through the many current technical periodicals containing "multa sed non multum," it is a relief to be reminded of the old "Dirt Mover," and particularly with an excellent selection of good stuff.

To my mind, your departure into "rotated specialization" is a step in the right direction, and I know several engineers and contractors who join me in those sentiments.

With best wishes, Yours faithfully,
Lee Heidenreich.

Kansas City, Mo., July 21, 1916.

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## OPINION ON AUTOMOBILIZING STEAM RAILWAYS.

To the Editors: The idea undoubtedly is feasible and we know of a number of cases where it is being done in one form or another. In fact several years ago we furnished the Little River R. R. at Townsend, Blount County, Tennessee, a motor truck which is being used on rails. Although we have not heard from these people for some time, it is our understanding that this proposition solved a hard problem for them and that through the South many such situations exist. We refer you to Mr. J. T. Murphy, manager of this company, who we believe would be in a position to give you a good idea of the practical working out of your theory.

Yours very truly,
E. H. Herbia,
Advertising Manager, Service Motor Truck Co.

Wabash, Ind.
July 24, 1916.

To the Editors: The point of view you express in this editorial is an exceedingly interesting one, and I am passing it through to our sales department for their perusal.

Sincerely yours,
The Thomas B. Jeffery Co.,
W. H. Needham, Advertising Manager.

Kenosha, Wis.,
July 21, 1916.

To the Editors: We, certainly endorse in the very highest terms everything that you say in your article regarding the automobilizing of our railway. We have often noticed and regretted the fact that motor trucks in use in hauling from freight depots in the large cities cannot possibly be used to their best advantage. The trouble and the reason for this is of course the fact that the loading platforms are so congested with other machines that the motor truck has to wait its turn, which often amounts to a great, big item every day. Motor trucks to be made profitable must be kept busy and this is impossible under the present system of railway freight management.

We cannot understand why the managers of the railway companies have not put into service before this time some part at least of the system that you have outlined in your article. We are taking this up very thoroughly with our own sales department and if everyone would do so, we certainly believe that railway managers would soon find themselves actually compelled to adopt some up-to-date system of freight handling and would thereby profit themselves and the public at large.

We wish to thank you for bringing this to our attention, and remain,

Yours very respectfully,
The Gramm-Bernstein Co.,
Fred Biszantz, Superintendent.

Lima, O.,
Aug. 2, 1916.

To the Editors: I have carefully digested the article covering the use of motor trucks on standard railways, and I believe that this method of transportation could be easily worked out, although it would require quite some scheming and mechanical manipulation to manufacture all sizes of motor trucks with the track of the proper width (56 in. to use on standard railways). You know our 2-ton trucks have a track of 62 in. and the 5-ton 68 and 74 in., and to narrow them down to the standard railroad gage would be rather difficult, owing to the fact that loads are so often unevenly distributed and in many cases would have a tendency to make the machine top-heavy should too narrow a gage be used.

If some such scheme as this were to be adopted, it would be necessary to lengthen the wheel base, while reducing the gage; to distribute the load over a longer surface, rather than a wider one.

There is also the problem of tires and the different sizes, widths and diameters involved. I believe it would be quite possible, however, to arrange the wheel for the track in an altogether different way than suggested; that is to say, equip the motor trucks probably with a set of wheels with steel rims and a flange exactly as railroad cars are equipped (excepting for the fact that they would be lighter) and have rubber tires that would slip on from the outside and up against the track flange in such a manner as to hold them firmly on the inside and to add the necessary clamps on the outside of the tire proper to hold it in its place, thus providing a regular steel rim for use on the railroad tracks and a removable tire when used on dirt or paved roads. Suitable carriers could be provided for these tires as part of the regular truck equipment when they are used on the rails. This method I believe would be far more rapid in the matter of changing than the way suggested.

At regular terminal or loading places there could be provided special runways or switches that would allow the truck driver to run the truck and load up on sort of an incline or special track way and on the rails providing for necessary guides to prevent the tires from slipping off the rails until the necessary change could be made.

I also believe it would be quite necessary to have an extra gear ratio provided that would enable the vehicle to run two or three times faster when on the rails than it should be driven on paved streets. This would also be a simple matter of engineering. In this manner a speed of 30 miles per hour or even greater could be attained on rails with loads up to five tons and greater, and when used on streets gear changes or ratios, about the present standard could be maintained.

It is also apparent that the railroad could not expect to use this method except where the regular transportation requirements are not large; or on separate tracks and a regular roadway bed could be provided. The absence of all bad grades or bad spots that are encountered ordinarily with a motor truck would be entirely eliminated in this manner as well as the very severe wear and tear there would be on the rubber tires if they were used on the rails. You know that to drive on an ordinary street car track with a motor truck or even a pleasure car tire is one of the most severe usages possible to put them to; it would not be long before a regular groove would be worn in the centers of the truck tires if this practice was followed, and owing to the surface of the tracks and the fact that all trucks are equipped with excellent springs no cushions would be necessary on what might be termed the rim or periphery of the rims.

Some of the more popular types of motor truck tires we manufacture now with a steel base would not require anything more than slight changes to provide for installation of the steel wheel flanges as I have suggested.

The Tiffin Wagon Co.,
W. K. Shelly,
Vice Pres. & Gen. Manager.

Tiffin, Ohio,
July 21, 1916.

To the Editors: We have read your editorial on automobilizing our railroads with great interest. We are perhaps biased somewhat in believing that a truer solution of transport problems would be to stop the railroad freight yards at the outskirts of the cities, as you suggest, and tranship the freight directly to ordinary road automobiles.

The sort of amphibious type of vehicle equally fitted to run on rails as on road is so much a compromise that it would probably not prove as economical under one or other of the conditions as would a vehicle especially designed.

Much time would be lost in preparing the road vehicle for the rails, uncoupling the steering gear, fitting in rail attachments, maneuvering over railroad ties, and so forth. A similar amount of time would be lost in reversing the process.

Again, there are many objections to the use of a two-axle vehicle on railorads. The railroad vehicle has an axle which allows of slight lateral displacement to accommodate itself to curves and points. The more rigid type of road axle would probably jump the tracks.

Consider, too, the small amount of freight that can be carried on a motor truck 20 ft. long over all and consider the vastly increased tonnage that can be carried on a similar freight car of the same overall length—when it will be seen that congestion would be increased rather than diminished. This would be made still worse by the fact that independent motor units require at least their own length of headway, and that change at switches would make for great delays.

Our opinion is that for the moderately short haul, say up to 100 miles or so, the motor truck is the most economical method of transportation when used solely on fair roads. To our mind, the time is not far distant when railways will be used for long distance haulage with trucks doing the terminal haulage by road as well as all kinds of haulage up to 100 or more miles.

The provisioning of Verdun with food and munitions greatly by motor trucks has been a wonderful object lesson which railroad people would do well to let sink into their minds.

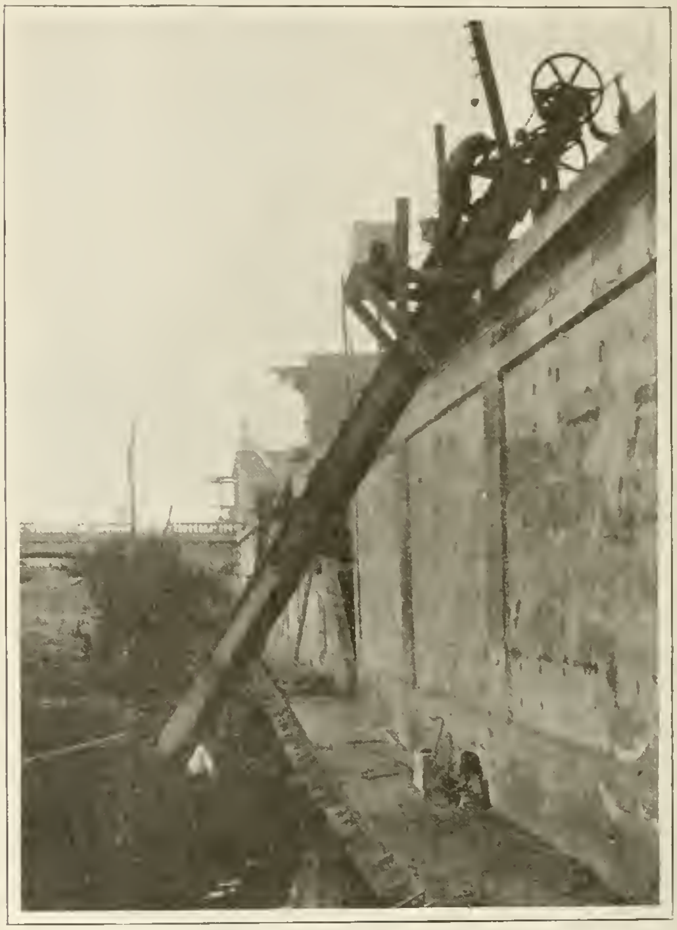
Yours very truly,
The Pierce-Arrow Motor Car Co.,
John Younger,
Chief Engineer Truck Department.

Buffalo, N. Y.
July 30, 1916.

## HOME-MADE CONVEYOR FOR BACKFILLING RETAINING WALL.

Contributed by W. F. Schaphorst, Woolworth Building, New York City.

A large river wall was very recently completed in Cedar Rapids, Iowa. This wall was of concrete and was 26 ft. high and designed to protect abutting property from the seasonal floods of the Red Cedar River. When the footings were built the mud excavated from the site was piled in front, forming an earth cofferdam. After the wall had been completed this same mud was used as backfill.



Backfilling Device for Filling Behind Retaining Wall.

The problem of moving the mud from in front of the wall to its desired position behind it was solved by the construction of a novel and effective ladder conveyor. The buckets of this conveyor, which is shown in the accompanying view, are wide strips of metal which slide up a plank at an angle of about 60 degrees with the plank and empty as they pass over the sprocket at the top. A gang of men at the bottom shoveled the mud into the buckets.

## METHODS OF REMOVING STUMPS BY BLASTING.

Contributed by Thomas M. Knight, E. I. Du Pont de Nemours Co., Wilmington, Del.

The removing of stumps is no longer dreaded by the contractor. In days past when they were taken out by the slow, tedious process of grubbing, the task was a real one, but now with improved methods, the operation is greatly simplified.

There are several factors that enter into and influence the character of the blast and determine the location and size of the charges. Among the principle ones are: Character of the roots, whether tap or fibrous; state of preservation and toughness of the roots, whether green or partially decayed; nature of the soil with regard to resisting properties; and, the moisture content of the soil. The loads and method must vary with regard to the above conditions.

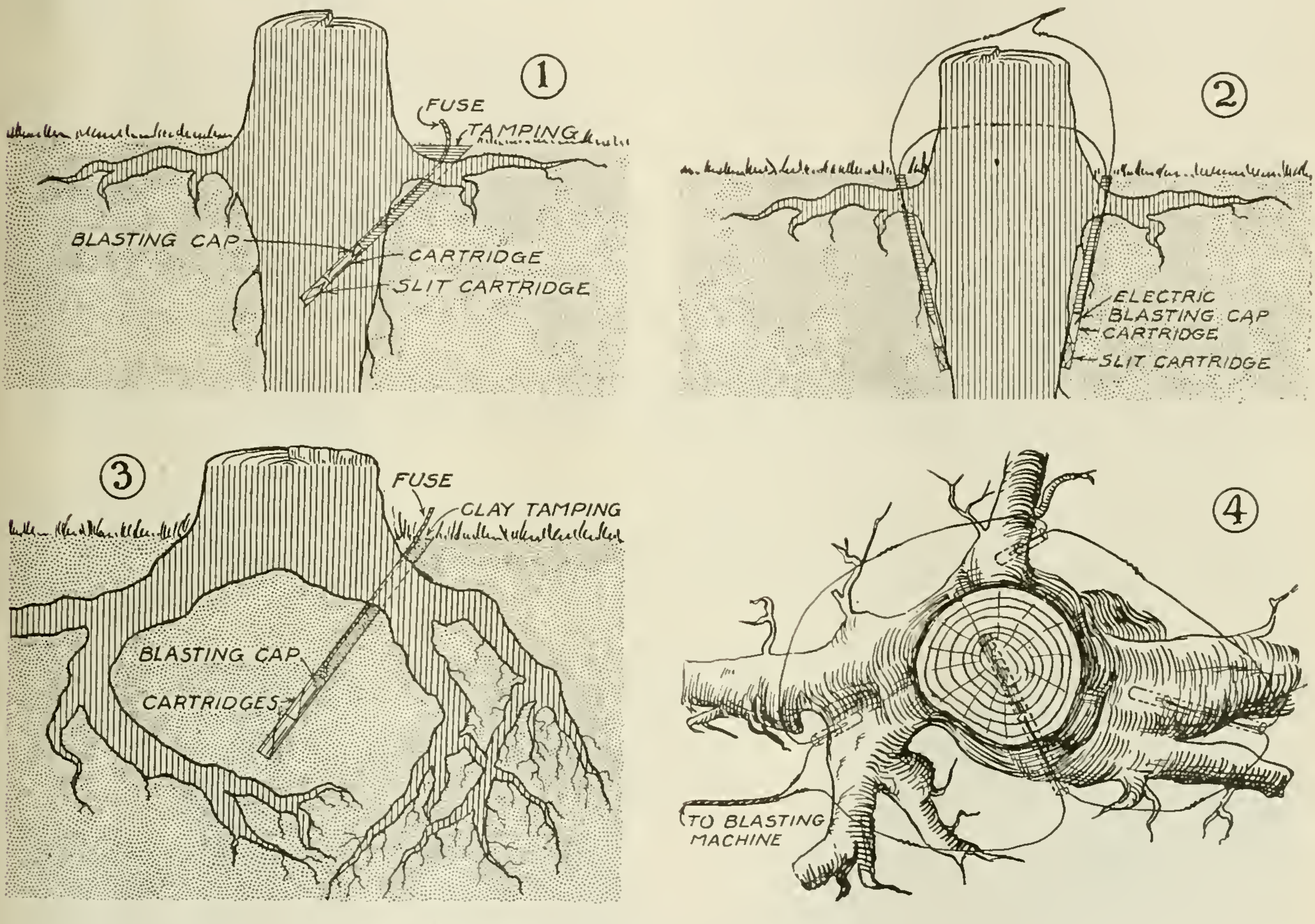
The root systems of the various families of forest trees are subject to great variations due to soil and other conditions. Generally speaking, stumps will be found with three kinds or classes of roots: Those having tap roots, those having long, lateral fibrous roots, and those that have both a small tap root and numerous fibrous roots. All of the classes are common, and it would be a hard matter to say which one class predominates.

There are several means employed to remove stumps, but the favorite way and the most economical one in the majority of cases, except in the even of small ones, is with dynamite. However, there are very often times when dynamite and stump pullers can work in conjunction to good advantage, and possibly cheaper than if either method were used separately.

When unobstructed by hardpan, trees like the pine send down a deep tap root. In blasting out stumps of trees like these a spade width of dirt is removed from the stump to a depth of about 18 in. A wood auger is then used to bore a hole into the root. The hole in the root should extend a little beyond the center; in this hole the charge is placed. No definite rule can be followed as to the amount of dynamite required, but after a few test shots the amount required can easily be determined. In the test shots it is better to overload than to underload, for if the charge tried is not of sufficient strength to lift out the stump, but only breaks or shatters it, it will be found difficult to blast out these pieces. If it is seen that too much dynamite is being used, the charge can be cut down in the next load. It is an excellent plan to try blasting out the smaller stumps first and gradually work up to the larger ones as the work becomes more familiar.

In loading a charge for a blast of this kind, two or three cartridges will generally be sufficient for stumps whose diameter ranges from 12 to 15 in. If three cartridges are used, two should be slit and inserted in the bore hole. The third is primed with a cap and fuse or electric blasting cap, and is placed on the top of the other cartridges, and the hole is tamped very tight. Figure 1 shows how a charge of this kind should be placed.

Another method of blasting out stumps of this class is to place two or more charges directly around and against the root at a depth of not less than 3½ ft. This method is generally employed on the larger tap-rooted stumps, although if the stump be green it may be necessary to proceed along the same lines on smaller ones. In a blast of this sort, the bore hole is put down along side of the stump to the required depth. Care should be taken that these bore holes are of sufficient depth, as the tap root of large stumps extends down to a considerable depth. The holes are loaded the same as previously described, except that an electric blasting cap is used instead of fuse and blasting cap. The charges are connected up and fired with the aid of a blasting machine. A good idea of the proper method of loading for blasts of this kind is shown in Fig. 2.



Methods of Placing Charges in Blasting Stumps.

In blasting out a small fibrous-rooted stump the charge should be placed so that the greater part of the dynamite required is directly under the heaviest part of the stump. There should be from 1½ to 2 ft. of earth between the charge and bottom of the stump as indicated in Fig. 3, else the force of the explosion will split the stump and roots and leave them in the ground instead of blowing them out. In starting to put down the bore hole this fact should be taken into consideration.

On a large fibrous-rooted stump will be found many roots of considerable size. In such a case the method just described will not be advisable. Charges must be placed under the largest of the roots, as well as having a main lifting charge under the center of the stump, and distributed so that the force of the explosion will blow them, together with the main stump, out instead of breaking them off. The location of the charges is determined by a careful survey of the stump, and bore holes are put down accordingly. Care is exercised to see that there are a few inches of dirt between the charge and roots as in the case of the smaller ones. Figure 4 gives a good idea of the proper location of charges in a shot of this root. The holes are loaded, charges are primed and fired electrically.

The method just described applies to the blasting out of hollow stumps as well.

Where a large fibrous-rooted stump is to be removed and a stump puller is to be used in conjunction with dynamite, the process of loading is the same as indicated in Fig. 3, except that the charge is placed directly under the heaviest part and against the stump instead of leaving a layer of dirt between charge and stump. The force of this blast splits the stump and loosens the roots, enabling the stump puller to easily complete the operation. The use of this method is advised only in connection with mechanical or power pullers.

It is hard to say whether any one grade or strength of dynamite is best for stump blasting. Generally speaking, a low-freezing or non-freezing dynamite from 20 per cent to 40 per cent strength will give satisfactory results. However, it is best not to use any dynamite of lower strength than 40 per cent when working in light or sandy soils.

Dynamite is the contractor's best friend and the stump's greatest enemy.

## A DUMPING PLATFORM FOR FLAT CARS.

A unique and efficient earth moving outfit was improvised in extending the main line railway of the Crossett Lumber Co., of Crossett, Ark. Flat cars only were available and a traction steam shovel. The arrangement devised, as shown by Fig. 1, was to mount the shovel on one flat car and couple a flat car in front and another behind, to form a three-car train hauled by a locomotive. The shovel, which was of the full circle type, loaded both cars. To equip these cars to dump their loads a dumping platform, as shown by Fig. 2, was devised. Two platforms 7 ft. wide were made of 2-in. plank spiked to three longitudinal timbers; at the outer edge was a 2x4-in. longitudinal and at the inner edge a 4x6-in. longitudinal and about a third of the width inward from the outer edge was another 4x6-in. longitudinal. The intermediate longitudinal set inside and against the car stakes. The two platforms were set on the car edge to edge and crotch lines attached to the inside edge timbers. The platforms were loaded by shovel and the train hauled to the fill; then the crotch line of one platform at a time was hooked onto the steam shovel dipper and the platform was tilted and dumped. Mr. J. R. Horton, roadmaster, who devised this grading train, writes that he can with it move dirt on a haul of 1,500 ft. for from 4 to 7 ct. per cubic yard.

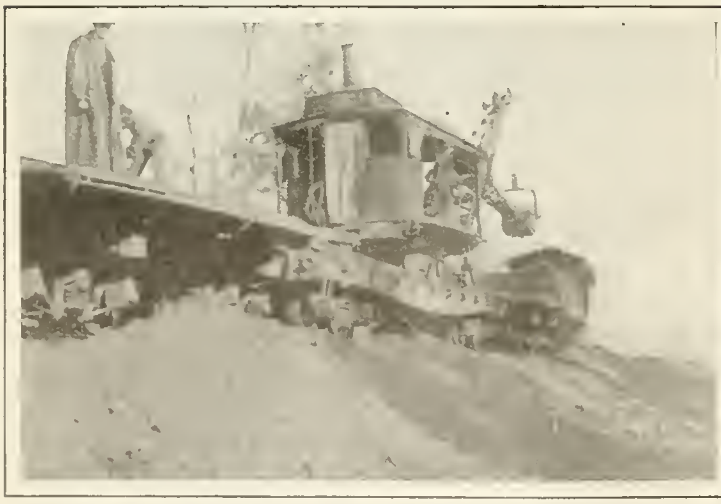


Fig. 1—Grading Train Crossett Lumber Co. Railway.

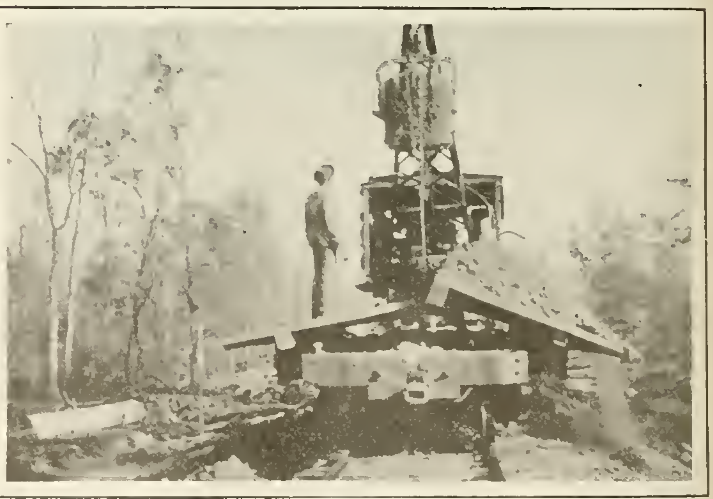
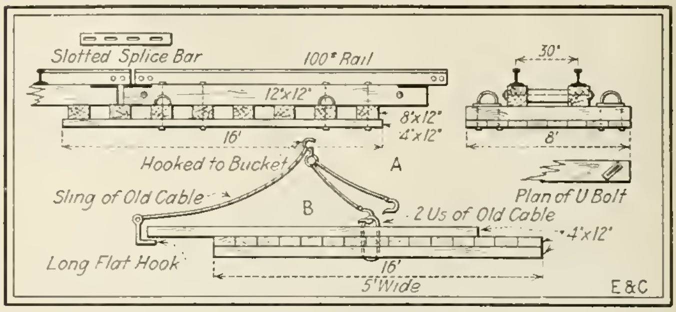


Fig. 2—Dumping Platform for Flat Cars.

## TIMBER TRACKWAY UNITS FOR DRAG LINE EXCAVATORS, LITTLE RIVER DRAINAGE DISTRICT.

Two forms of excavator trackway units developed on the work of the Little River drainage district, near Cape Girardeau, Mo., are illustrated at A and B on Fig. 1. The excavators used on this work are 175 to 200-ton Bucyrus drag line machines, some mounted on trucks and others on caterpillar tractions or on rollers. The trackway unit for the truck mounted machines is shown at A and that for the roller mounted machines at B. These drawings show all essential structural features and dimensions. Features to be noted are the overlap of each unit onto the next and the sling for handling the unit by the excavator. The contractor using these trackway units is the Floesch Construction Co., Cape Giradeau, Mo.



Trackway Units for Drag Line Excavators.

## PROGRESS AND METHOD OF EXCAVATING ROGERS PASS TUNNEL, CANADIAN PACIFIC RY.*

The Rogers Pass Tunnel is in the Selkirk Mountains of British Columbia. It is double tracked, five miles long, and as shown, lowers the summit of the former line by 552 ft. It also shortens the line by 4.3 miles, eliminates some 2,300 or 2,400 degrees of curvature and avoids the expense and danger of maintaining and operating 4.5 miles of snow sheds.

A pioneer tunnel was driven entirely outside the regular section of the tunnel, and a center heading was driven along the center of the main tunnel. The functions of the pioneer tunnel were to provide a means of transporting the material from the heading to a point back of where the enlargement of the tunnel was being made, and to provide for the carrying of high pressure air pipes, water pipes, ventilating section pipes, etc. In other words, to provide a means whereby the "shooting" at any one point in the tunnel would not interfere with operations at other points. It was supposed that heavy drills, such as have been used in the past, would be necessary, but it was found that the Leyner drills actually used were so light that they could be handled by one man. The result has been that all drilling in the enlargement has been done from vertical shafts as shown in Fig. 2.

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*Extract from a paper by J. G. Sullivan before the Canadian Society of Civil Engineers.

Fig. 1 is a progress diagram, and shows the condition of the work to Dec. 19, 1915. The pioneer tunnel at the east end was located 50 ft. to the north of the center line of the main tunnel and the pioneer tunnel at the west end 50 ft. to the south of the center line of the main tunnel. The mode of operation was as follows: Drilling in the small headings was done in the usual manner, using in general Leyner drills, making an advance of 6 or 7 ft. for each round of holes. The muck was shoveled by hand from steel plates into "half-yard" cars and hauled back, either by a mule or small compressed air locomotive. The latter was used entirely when the haul had reached a considerable distance. The muck from the headings A and B on the progress diagram was carried out through the cross-cuts E and D respectively into the pioneer tunnel, where it was carried back to cross-cut C, and thence out on a trestle over the standard-gage tracks through the main tunnel, and dumped into standard-gage cars. The material was then removed to the fills as was also the muck loaded by steam shovels in the enlargement. The muck from heading F on the west end was in a similar manner conveyed into the pioneer tunnel at cross-cut H and back to the main tunnel in cross-cut G, where it was dumped into standard-gage cars. In the enlargement of the main tunnel the drilling was done well ahead of the shooting. Fig. 2 shows the manner in which the drilling was carried out. The radial holes were at first drilled at right angles to the axis of the tunnel, but the results were not satisfactory, and a change was made to the method shown, in which the holes have an inclination of about 1 in 4 from the direction in which the tunnel was being driven. The muck was all loaded by steam shovels into standard-gage 12-cu. yd. capacity dump cars. The shovels had dippers of $1\frac{1}{2}$-cu. yd. capacity and were worked by compressed air. The cars were hauled to the mouth of the tunnel by standard-gage compressed air locomotives and taken from there to the dumps by standard steam locomotives.

The contract for this work was let on July 1, 1913. The limit of time for completion was $3\frac{1}{2}$ years, which would end on Jan. 1, 1917. There was an allowance in extension of time of one day for every 10 ft. of soft ground encountered, which would require immediate timbering. As there was some 1,660 ft. of such ground, the time limit of the contract was extended into June, 1917.

The work completed up to Dec. 19, 1915, was as follows: 19,610 ft. of pioneer tunnel, 24,612 ft. of center heading, 1,660 ft. of earth tunnel, and 14,342 ft. of tunnel enlargement in rock.

At the same date there remained to be driven: 288 ft. of center heading and 10,398 ft. of tunnel enlargement.

The best progress made in driving the pioneer tunnel heading was in the month of January, 1915, when 932 ft.

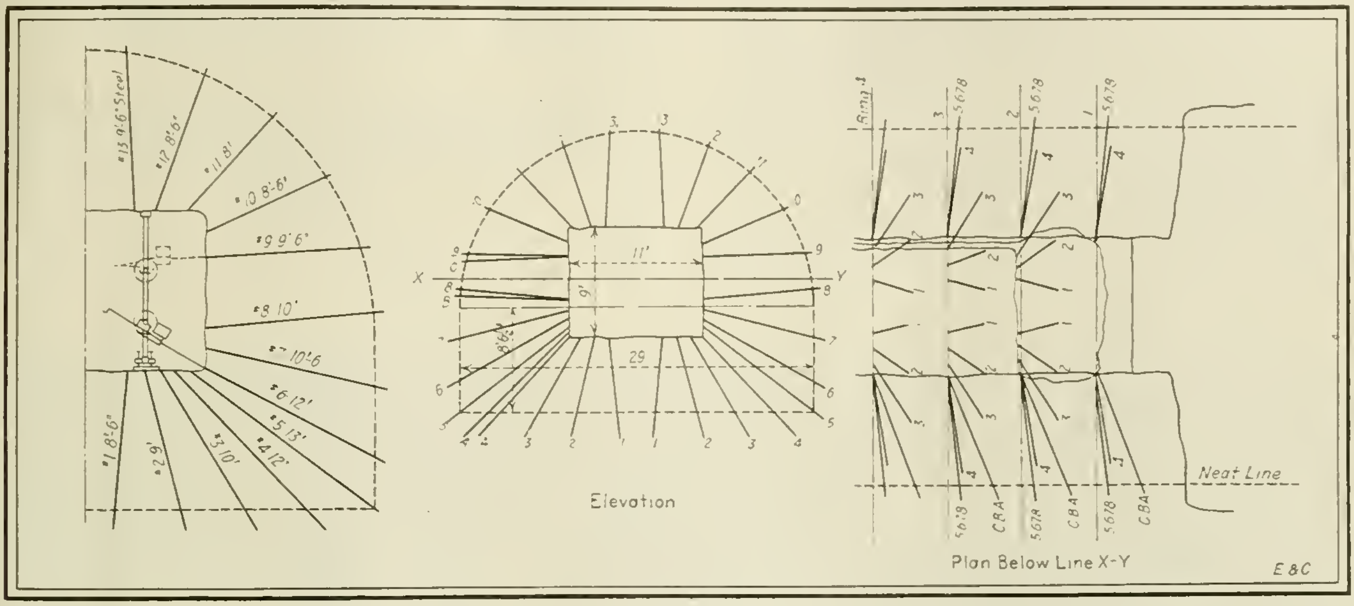


FIG. 1—DRILLING AND SHOOTING FOR ENLARGEMENT, ROGERS PASS TUNNEL.
First Shot: Ring 1, holes 4, 5, 6, 7, 8, A, B; Ring 2, holes 1, 2, 3. Second Shot: Ring 2, holes 4, 5, 6, 7, 8, A, B; Ring 3, holes 1, 2, 3. Third Shot: Ring 3, holes 4, 5, 6, 7, 8, A, B; Ring 4, holes 1, 2, 3. After sufficient number of shots have been made as above (usually five or six rings), the holes above the line XY are shot (holes 9, 10, 11, 12, 13, C), one or two rings at a time, depending on the nature of the rock.

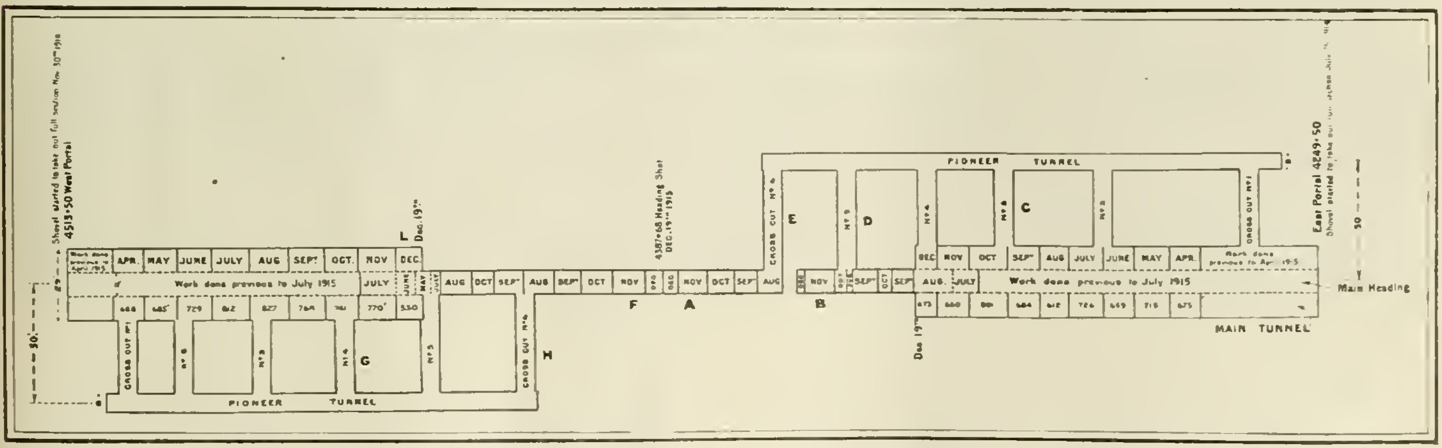

Shovel started to take out full section Nov. 30th 1914
4513+50 West Portal
4357+68 Heading Shot Dec. 19th 1915
East Portal 4249+50
PIONEER TUNNEL
MAIN TUNNEL
Main Heading
Work done previous to July 1915
APR. MAY JUNE JULY AUG SEPT OCT. NOV DEC
CROSS CUT
A
B
C
D
E
F
G
H
L
Dec. 19th
50'

FIG.2 —DIAGRAM SHOWING PROCEDURE AND PROGRESS OF EXCAVATING ROGERS PASS TUNNEL.

in the west heading were completed. The best record for a week in the enlargement was 267 ft., and for a month 827 ft. The latter distance was accomplished during the month of August, 1915, in the west end.

From April 1, 1915, to Dec. 19, 1915, 12,346 ft. of tunnel enlargement was made. This was during the time that the shovels were both working in rock and at a normal rate of speed. The methods employed in shooting in the enlargement were as follows: One round of holes was shot a time, the holes in the bottom of the tunnel being shot in advance of the holes on the sides or on top. (See Fig 2.) In some cases the top holes were not shot until all the bottom holes were finished. Usually six or seven rounds of holes were shot before the steam shovel began to take up the muck, thus making an advance of from 30 to 35 ft. The shooting was usually continued until the tunnel became so full of muck that no more shooting could be done. The largest amount shot at one time was 84 ft. in 11 hours.

All expectations as to speed in the execution of the work have been more than realized. For rock tunneling where the rock is of sufficient hardness to stand until the mucking has been completed, the method described can be most successfully worked, and a speed of three miles a year can be easily made at a much less cost than tunnels driven at the same speed by the European method. Furthermore, the practice of radial shooting has given a great deal less overbreak than would have resulted had the holes been drilled parallel to the axis of the tunnel.

The work was laid out and commenced under Mr. F. F. Busteed, Engineer in charge of double tracking, with Mr. J. W. Sheppard as Assistant Engineer. It has recently been under the supervision of Mr. W. A. James, Engineer of construction western lines, with Mr. H. G. Barber as Assistant Engineer, Mr. T. Main, Resident Engineer at the west end and Mrs. J. R. C. Macredie, Resident Engineer at the east end. The contractors are Messrs. Foley Bros., Welch & Stewart. The construction work has been supervised for the contractors by Mr. A. C. Dennis.

## SPECIAL DEVICE AND PROCEDURE FOR CROSS-SECTIONING TUNNELS.*

This device consists of a triangular A-frame of wood with a crosspiece in the center of the frame, supporting an upright piece 5 ft. 6 in. long. A leveling screw is placed at the apex of the A-frame, and a level bubble on the crosspiece. To the upright is attached a circular protractor 24 in. in diameter, so placed that the center of the protractor will be 4 ft. 6 in. above base of rail on tangents. This protractor is graduated to single degrees from 0 to 360 reading from left to right in the clockwise direction, zero being at the bottom of the protractor.

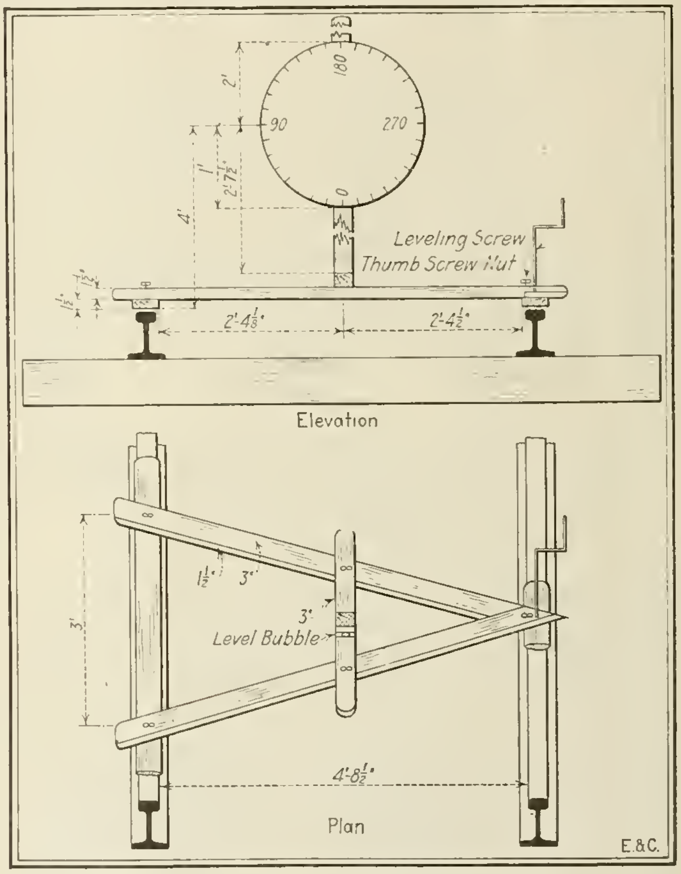
The protractor is made of two pieces of wood ¼ in. in thickness, glued together with grain crossed in order to prevent warping. The A-frame is put together with bolts secured with thumbscrew nuts in order that it can be taken apart and readily carried about, also can be stored when not in use without occupying much space. The device was made by the car department at the Paducah shops.

When a tunnel section is to be taken the A-frame is placed upon the rails of the track and is held in place by iron cleats. The frame is then leveled by means of the leveling screw referred to above. The level bubble on the center of the crosspiece which supports the upright is a guide for leveling the device. A plumb-bob line is also used in order to be absolutely certain that the upright piece is vertical.

In taking the cross-section, an ordinary 13-ft. level rod is placed at points where readings are to be taken and held against the face of the protractor, one edge on line with center of same. Angle and distance (the only measurements necessary to be taken) are recordd in an engineer's cross-section notebook. The rod is brought into contact with the controlling points of the tunnel outline, which are those of the greatest projection and depression of the surface. Cross-sections are taken at sufficient intervals to accurately determine excavation quantities, as in all earthwork measurements.

Three men are required to operate the tunnel measuring device. One man holds the rod and reads distances and angles, the levelman directs the work and records notes, and the third man holds a light. The device is always set so the protractor faces toward zero station, and readings are taken and recorded from left to right, thereby as far as possible eliminating chances of errors. It can be set up, and a section taken in from 10 to 15 minutes.

The field notes are platted in the office, and the tunnel section is reproduced to some convenient scale, the office protractor being set at the same distance above base of rail or grade as the field instrument measures. The height of protractor above base rail is recorded in the field, as it varies on curves due to elevation of outer rail. The points platted on the cross-section sheet are joined by lines, and the area is determined by the planimeter or by calculations based on the triangles of which the figure is composed. The data taken are simple to record, and can be as readily platted and computed in the office as data taken by any other method.



Protractor Device for Measuring Tunnel Cross-Section.

The actual cost of securing cross-sections of Montgomery tunnel, which is an unlined rock tunnel 252 ft. long, was $4.16, or less than 2 ct. per linear foot. Six sections were taken in this tunnel, averaging about 20 readings each. During the progress of measuring this tunnel it was necessary to take up the device and move it outside the tunnel five times in order to permit passage of trains. Had it not been for this, the cost of measuring this tunnel would have been reduced one-half, or to about 1 ct. per linear foot of tunnel. However, similar delays are to be expected in every tunnel through which trains are operated, and the 2 ct. cost per foot of measuring Montgomery tunnel may be taken as a fair average for doing this class of work.

Comparing this method of measuring tunnels with the ordinary method of using a wye level and tape, it should be noted first that the level and tape method requires five men as against three with the measuring device. Of these five men, one man reads the wye level and records notes, two men operate rod and tape, another holds a light to illuminate the cross-hairs of the level, and the fifth holds a light for reading rod and tape. On account of difficulty of reaching points in the roof of the tunnel by the latter method, and the necessity of holding the level rod plumb and keeping the tape truly horizontal, the tunnel outline can not be as accurately determined in this way as by the use of the device described above. Also, owing to difficulty of reading wye level and operating rod and tape, it takes more than twice as long to secure each cross-section with wye level, rod and tape, so that the cost of the work would be more than doubled thereby.

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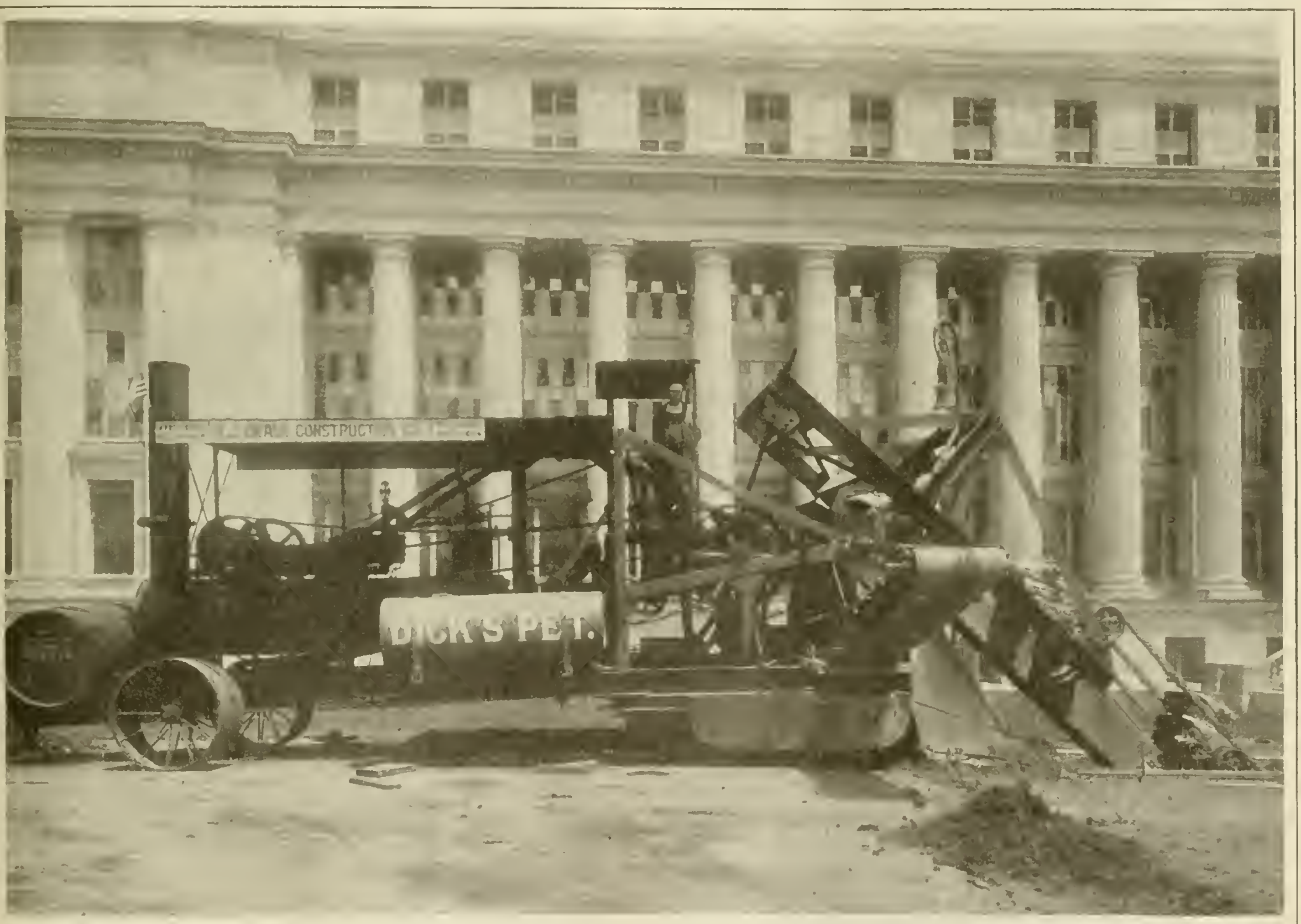
*From an article ir Illinois Central R. R. Employes' Magazine by T. H. Robertson, Assistant Engineer, Valuation Department.

## TRENCH EXCAVATION AND A CLEAN STREET.

A thoroughfare obstructed by mountainous spoil banks and general litter is the conventional picture of a street being trenched for underground pipes. The accompanying view shows a variation. The work is being done in Washington, D. C. Trench for conduit is being dug across public building grounds and through streets fronted by public buildings and the usual spoil banks and encumbering litter were required to be eliminated to the fullest degree possible. As the first means to this end excavation by trench excavator was decided on. This insured rapid opening of trench and also limited the length of trench section required to be under construction at any moment. A more important advantage, however, was that the trench excavator could discharge the earth just as it was excavated directly into dump wagons driven under the spoil conveyor belt. The wagons carried the spoil to the rear for backfilling or away to dumping grounds in case of samples. The little pile of earth shown in the illustration was all that obstructed the street at any time and this was cleaned up with shovels as soon as the first dump wagon arrived. The contractor for this work was the R. J. Beal Construction Co., Washington, D. C., and the excavator used was the standard machine made by the F. C. Austin Drainage Excavator Co., Chicago, Ill.



Street Trenching Without Spoil Banks.

## WELL DRILLING IN MODERN QUARRYING.*

The well drill or cable drill method of working a quarry face is now in quite common use. The use of large drills is constantly increasing among quarrymen. In fact the growing tendency is for large machinery of all kinds, such as mammoth crushers, steam shovels, etc. Volume is what is wanted nowadays.

The advantages of the big drill over the piston driven drill are numerous. By carrying the holes the full depth of the face the stone is loaded and treated on one working floor. It eliminates the cost of bench cleaning. Loading operations are less frequent, thus lessening the danger. Stone can be shot down in greater volume and in better shape, making it economical to use a steam shovel. No bench cleaning makes it safer for the men. It is cheaper and can be used in outlying and temporary operations where the cost of installing a power plant would be out of the question. It permits a greater spacing of bore holes and eliminates the necessity of "squibbing" or springing.

In this method usually holes from 4 in. to 6 in. in diameter are drilled the full depth of the face from 15 ft. to 20 ft. apart and as far back and the whole face shot down at one time.

The cost of well drilling may vary all the way from 20 ct. to 75 ct. per foot, and in extremely hard rocks up to $1.50 per foot. In the flat laminated rocks of the Middle West as much as 75 ft. of hole can be drilled per day, while in the harder pitching rocks, common in the East, from 25 ft. to 40 ft. per day is considered good.

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*Extract from paper by S. R. Russell, read before the Du Pont Sales Convention, February, 1916.

I know of a few places where 5 or 6 ft. per day is all that can be made.

These drills are best adapted where the strata are flat and the height of the face exceeds 25 ft. When used in harder rocks it is best to drill a $5\frac{5}{8}$-in. hole because it is possible to concentrate more explosives in the bottom where it is usually most needed and the larger hole permits greater spacing, hence minimum drilling cost.

In lighter materials such as shale or sandstones or even in some limestones with a shallow face it may be more economical sometimes to use a 4-in. or $4\frac{1}{2}$-in. bit, because not so much concentration as distribution may be desirable and a considerable saving of explosives can be made. A $5\frac{5}{8}$-in. hole requires about 15 lb. of dynamite and a 4-in. hole only about $7\frac{1}{2}$ lb. to fill 1 ft.

Spacing of holes depends on the character of the material and the depth of the face. A nice spacing for holes 35 ft. deep is about 12 ft. apart and 15 ft. back. Holes 60 ft. deep can be spaced 16 ft. x 20 ft. and holes 100 ft. or more 20 ft. apart and 25 ft. back in most materials. I don't believe it advisable to ever space more than 20 ft. apart.

Holes should be drilled 3 or 4 ft. below the quarry floor, unless there is a natural parting at that level, in which case, if holes are sunk to grade the bottoms will come clean. Going below the floor insures better breakage, cleaner floor and permits easy access for a steam shovel if used.

No rule can be given as to the amount of dynamite to load in holes of given depth; all depends on local conditions. The important part is the selection of the proper explosive to produce the desired results. Explosives differ widely in their action and what would suit one condition may not fit another.

I usually before loading calculate the number of tons or cubic yards available in the blast and then aim to get about 5 tons of stone per pound of explosive, varying the load per hole according to the burden or local conditions.

In deep holes considerable saving can be made by breaking the load two or three times with equally good results. The object in breaking the load, besides saving explosives, is to distribute the charge where the rick is hardest, skipping seams and weak points where it is not needed. It is good policy to arrange the breaks so that they are not all on the same level. This amounts to the same thing as shooting two or more benches simultaneously.

In loading deep holes there is little gained by removing the paper and loading the dynamite loose or in bulk. In fact the danger is increased by so doing as loose powder may be scattered all along the walls of the hole and at the mouth. When this occurs there is danger of a stone working loose, getting wedged between the tamping block and wall, causing friction and setting off the charge.

Before loading all the water possible should be removed from the holes. There is always some water in well drill holes which cannot be removed. It is advisable to use large cartridges as they are much more convenient and lighten the labor considerably in loading.

If holes are loaded in cold weather care should be taken to see that the explosives are properly thawed.

As a usual thing well drill holes are driven and blasted in one line, holes being equidistant from the face. Occasionally in very hard ground better results are obtained by staggering the holes. There is also another method known as "buffer" shooting or shooting against the bank. By this is meant that a line of holes is shot down and then another line drilled and blasted before the debris from the previous shot is removed. This method is well adapted in limestone formations where the stone is flat and thinly laminated on top. It is only necessary to loosen or push out the bottom in such a formation. It eliminates the necessity of lifting and laying tracks or moving the shovel so frequently as when clear bank method is used.

In hard rocks a combination of 60 per cent and 40 per cent dynamite is recommended. A little 60 per cent should be loaded in the bottom of each hole and 40 per cent used on top. In softer flat limestones a 40 per cent explosive will usually be found strong enough and often a lower grade can be used for top load. If the work is very wet and the toe heavy it may be necessary to use a gelatin dynamite from 40 per cent to 60 per cent strength.

It seems unnecessary to say that strong detonators should always be used, at least No. 6 Electric Blasting Caps, and better still, No. 8. If holes are double or triple loaded at least two electric blasting caps should be used in each charge unit to assure thorough detonation and to afford a way out in case one should be broken or otherwise spoiled during tampering. I have found electric blasting caps with duplex wire leads a great convenience in loading deep holes.

They are handier, stronger, and better than those with two single leads. Oftentimes short length electric blasting caps are used and connecting wire spliced to make necessary length. A good scheme followed in one big operation is to use wires with colored insulation, splicing a red wire to one leg and a blue to the other.

When final connections are made—parallel method—the red wires are connected to one lead and blue to the other. There is no chance of a mistake if this is done.

Sand, clay or fine screenings should be used for tamping and holes filled up to the collar. In holes up to 35 ft. deep a tamping hole or stick can be used handily. If of greater depth it is necessary to use a rope and block as a tamper.

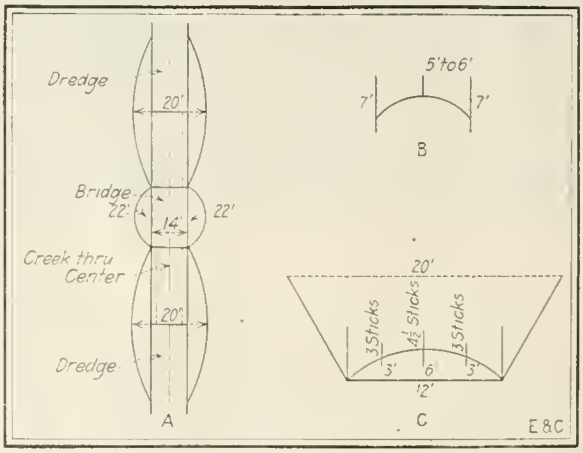
A tamping block should be of wood about 4 ft. long and from 3 in. to 4 in. in diameter with a rope fastened at one end. For very deep holes a light tripod can be built and the block operated by two men with the rope over a pulley at the apex.

Each electric blasting cap should be tested for circuit with a reliable galvanometer before being placed in the hole. When all the holes are loaded and connections made be sure by test that the resistance of the circuit does not exceed the capacity of the blasting machine or power circuit and fire the blast as soon as possible after loading is completed.

## DYNAMITING A DREDGEWAY UNDER A BRIDGE.

Contributed by Paul R. Higgings, Lake City, Iowa.

A small creek ran under a concrete bridge 22 ft. in width. It was desired to run dredges under the bridge, but the creek was not deep enough, nor wide enough. I was given the contract at a price of 80 ct. per cubic yard to deepen and widen the creek for 60 ft. on either side of the bridge.



Method of Enlarging a Creek Bed by Dynamite.

I began operations directly under the bridge. It was impracticable to load heavy charges at that point, so I put down a row of bore holes 2 ft. back from the bank of the stream, spacing them 2 ft. apart and making them 2 ft. deep. Each hole was loaded with a half stick of 60 per cent dynamite. I worked in this way from both ends toward the middle. It was necessary for me to make use of these little shots at the 2-ft. distances all the way down these lines in order to get the required excavation.

This method of blasting resulted in throwing most of the dirt into the creek bed, which was at that time dry. Two hours' work with team and scraper at a cost of 50 ct. per hour were required to remove the dirt.

After finishing under the bridge, the work was much easier, as I could load more heavily. Parallel rows of holes were put down on either side of the creek 2 ft. back from the banks, 6 ft. deep and 4 ft. apart, each hole loaded with from seven to nine sticks of the 60 per cent dynamite. An electric cap was used in each charge and the charges were fired electrically. The accompanying diagram, A. Fig. 1, will illustrate this operation. These side blasts threw most of the dirt over into the dry creek bottom, leaving the work in the condition indicated by diagram B Fig 1.

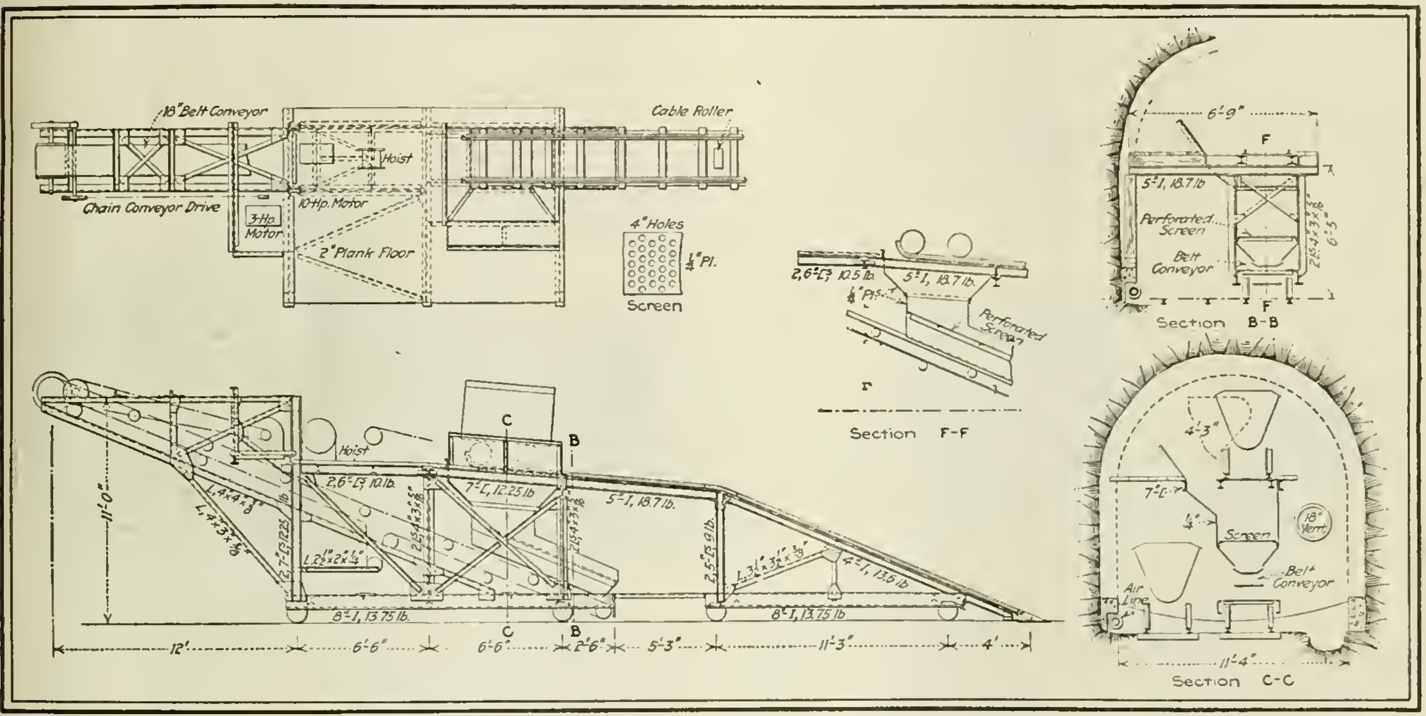
I then put down a single row of holes directly down the center of the hump, also two more parallel rows of holes on either side of the center line. These side lines were each about 3 ft. from the center line. The center line of holes was about 6 ft. deep; the side lines from 3 to 4 ft. My center line of holes (all the holes were from 2 to 3 ft. apart) was loaded with about 4½ cartridges each of the straight dynamite, and the side line of holes with about three cartridges each.

This final shot resulted in throwing the dirt out on the banks, leaving a nice clear ditch nearly 20 ft. wide at the top and about 12 ft. wide at the bottom. Diagram C Fig 1 will illustrate the loading for this last shot and the approximate shape of the ditch after the blast.

## UTILIZING TUNNEL SPOIL FOR CONCRETE LINING WITHOUT REMOVAL FROM TUNNEL.

In excavating the Wilson Ave. water works tunnel now under construction, it was found that much of the rock excavated broke very small in blasting. Tests of the finer portions of this blasted rock in concrete blocks and also in above ground preliminary construction demonstrated that it made an excellent concrete and the natural conclusion was that it could advantageously be utilized in concrete lining the tunnel. The economic way, it was also seen, would be to use the rock without removing it from the tunnel. The plan developed is a novelty in tunnel construction and is indicated in diagram by the accompanying drawings. It involved the construction of two within tunnel travelers, one carrying a pneumatic concrete mixer and its appurtenances and one combining a spiral car incline, a stone screen and a belt conveyor. Only the latter traveler is illustrated. The conveyor on cantilever end overhangs the hopper of the mixer mounted on the smaller traveler.

The method of placing the concrete lining was described in our issue of May —, 1916, and will not be referred to further here. The tunnel spoil tracks were 20-in. gage and were 4 ft. between centers, and both travelers had to be designed to travel on one track and leave the other track unobstructed for spoil cars. The manner of accomplishing this and yet have ample platform space on the traveler is indicated by the drawings. As shown, the traveler is of steel; it is mounted on steel wheels with steel roller bearings and carries an inclined car track, a hopper and a screen, a belt conveyor and the motors for operating the conveyor belt and the car hoist. In operation cars coming from the working face on the free track, are switched to the traveler track, hauled up the incline and dumped onto the screen. The fine spoil under 4 in. passes through the screen and the conveyor belt and is carried to the concrete mixer hopper. The rejected rock is chuted from the screen onto the tunnel floor and thence is shoveled into cars and taken out of the tunnel.



Traveler for Screening Tunnel Spoil for Concrete Lining.

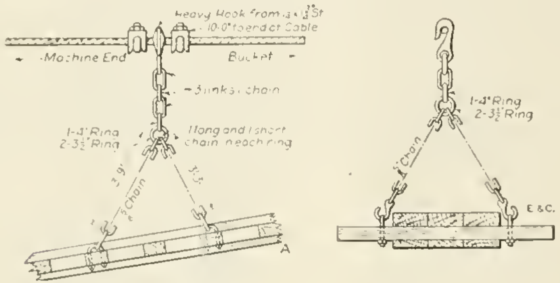
The plant has worked successfully. Only such spoil cars as are needed to supply stone for concrete are diverted to it, the other cars passing freely out of the tunnell so that no delay to excavation for removing spoil is caused. Lining is simultaneous with excavation, thus cutting down the total time of construction. And, as noted before, the stone required for concrete lining does not have to be handled out of the tunnel and back again. The tunnel construction is under the direction of Mr. Henry W. Clausen, engineer of water works construction, Chicago, with Mr. John Ericson, City Engineer, and H. S. Baker, Assistant City Engineer. The pneumatic concrete mixer and conveyor system is that of the Concrete Mixing & Placing Co., Chicago, Ill.

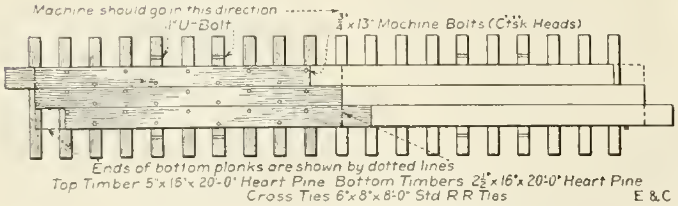
## DRAG LINE EXCAVATOR TRACKWAY FOR LEVEE CONSTRUCTION, BATON ROUGE, LA.

On levee enlargement using drag line excavators near Baton Rouge, La., the contractors, Don B. Hearin & Son, had much bog and soft ground to traverse. To keep the machines up in covering this soft ground the trackway illustrated was devised. Mention was made some time ago of this trackway, but it is reillustrated here to supplement the other three designs presented.

The unit is 24 ft. in length over all. Ten of them are used, five under each side of the machine, giving a track of about 100 ft. in length. Each consists of three 5x16-in. x 20-ft. stringers laid side by side, thus forming a roller bed 4 ft. wide. Under these are placed ten 6x2-in. x 8-ft. standard railway cross-ties, spaced 2 ft. apart. Under these are three 2½x16-in. x 20-ft. flooring planks, to serve as a stiffener, to elevate the roller bed and to keep the mud from forcing itself up between the ties. These three sets of timbers are bolted together by thirty ¾x13-in. machine bolts with heads countersunk below the surface of the top timbers. Four 1-in. U-bolts in the ties serve for hooking the swinging chains.

The chief feature of the section is the staggered arrangement of the top timbers. The advantage of this is, first, to break the joint and make a more rigid connection; and, second, to make it possible to take a sharp curve in the shortest possible space. The rollers in so doing always have a solid bearing over the joint.




Machine should go in this direction
1" U-Bolt
¾"x13" Machine Bolts (Ctsk Heads)
Ends of bottom planks are shown by dotted lines
Top Timber 5"x16"x 20'-0" Heart Pine
Bottom Timbers 2½"x16"x20'-0" Heart Pine
Cross Ties 6"x8"x8'-0" Std R R Ties
E & C

Trackway Unit for Drag Line Excavator.

The machine can run in either direction on these sections, but preferably in the direction of the arrow. The reason is that the rollers won't strike a projecting joint, since the top timbers on the section the dragline is on project over the ties on the section onto which it is moving and the weight of the machine serves to press it down. This is especially important on soft ground. Furthermore, it is easier to pick up and place the sections under this condition.

For very soft ground the bottom flooring may be extended to the end of the ties, thus giving more bearing surface.

An important point for the successful handling of these sections is the chain rigging for picking up and swinging. This consists of two pieces of ⅝-in. chain 3 ft. 9 in. long, and two pieces 3 ft. 3 in. long. The sketches show the arrangement. It will be observed that two of these chains are 6 in. longer than those hooked to the other end. The reason for this is that in swinging one end is higher than the other, thus making it easy to make a perfect joint.

All sections must be placed in the runway just as they came out. Under ordinary circumstances the act of swinging them from the rear to the front of the machine would set them wrong end for end. The long chains, therefore, should be given one-half twist. When the section is in the air its own weight will naturally swing it to the correct position.

When the pit men put on the chains the end nearest the operator should have the short chains, so that after swinging around the long chains, or low end, are nearest the operator.

For ordinary service two cable clamps are put on the dragline cable, 3 in. apart and about 10 ft. from the end. The large hook is hooked between these. In moving any distance the chains are fastened to the dragline by means of an ordinary cable clamp around the shank of the hook, thus preventing it from becoming unhooked.

The sections, if properly managed, may thus be swung ahead and placed in 1½ minutes each. The contractor states that these sections enabled him to move his machine 2,600 ft. in 10 hours.

## PULLING TRENCH SHEETING WITH A POWER BACKFILLER.

The illustration is an excellent view of a gasoline power backfiller pulling trench sheeting, one of the several tasks of sewer construction, besides backfilling trenches, to which this type of machine is being applied. The procedure followed is clearly indicated by the illustration. An across-trench "horse" carries the pulling tackle from which the line goes to the drum of the backfiller. The tackle is so slung as to be easily shifted from one to the other end of the horse so as to be directly over the sheeting being pulled. The horse shown in the illustration was a trial construction and has since been replaced by another somewhat taller and of more finished construction. Preparatory to pulling sheeting the ground is soaked over night with water. With this arrangement the contractors have pulled 3x12-in x 16-ft. sheeting for from $2.50 to $3 per thousand feet. The work illustrated is conduit trench for the Central Heating, Lighting and Power Plant at Washington, D. C. The contractors are the R. J. Beal Construction Co., Washington, D. C., and the backfiller is one manufactured by the F. C. Austin Drainage Excavator Co., Chicago, Ill.

Pulling Trench Sheeting With an Austin Power Trench Backfiller.

## A SELF-PROPELLING GRAB BUCKET CRANE EXCAVATOR AND UNLOADER.

The machine shown by the accompanying illustration and called by the makers an auto crane, is adapted to a wide variety of construction purposes, such as excavation, ditching, backfilling and loading and unloading broken stone, gravel and other loose material. For road work the machine has a notable use in unloading stone from cars to bin as shown by the illustration. In future machines there will be an all steel cab with open sides. The main structural and operating features are scheduled by the makers, the John F. Byers Machine Co., Ravenna, O., as follows:

The principal dimensions are: Car body, 17 ft. 4 in. long by 6½ ft .wide; width outside wheels (forward and rear wheels track), 9½ ft.; wheel base, 15 ft. 4 in.; height from ground to top of A frame, 12 ft.; (boom easily lowered and stack removed for close clearances);

width outside outriggers (folding), 18 ft.; size bucket to use, ½-yd. clam shell or 12-ft. orange peel; capacity as a derrick, 4,000 lb.; length of boom, 20 ft. for heavy bucket or derrick, 26 ft. for light bucket; weight complete without bucket, 19,500 lb.

The frame is constructed of heavy section deep steel channels, hot riveted, plated, cross braced and trussed. Mast and A-frame heavy steel construction. Outriggers: Heavy steel angles, hinged top and bottom, easily folded out of way. Adjustment secured by screw jacks permanently attached to ends of outrigger.

The trucks are: Three point suspension; propelling wheels 38 in. in diameter by 10-in. face by ¾-in. tires, to which are attached sprockets driven by heavy steel pintle chain. Propelling wheels equipped with a differential. Steering wheels 30-in. diameter by 10-in. face by ¾-in. tires mounted on pivoted axle with fifth wheel and kingbolt, steering by hand wheel and worm. Axles, 3½ in. square solid steel, blocked and trussed, with ends turned down to 3 7/16 in. x 10 in. for wheel bearings. Emergency band brake provided. Wheels drilled for attaching spuds if desired. Propelling speed, forward or reverse, 200 ft. per minute.

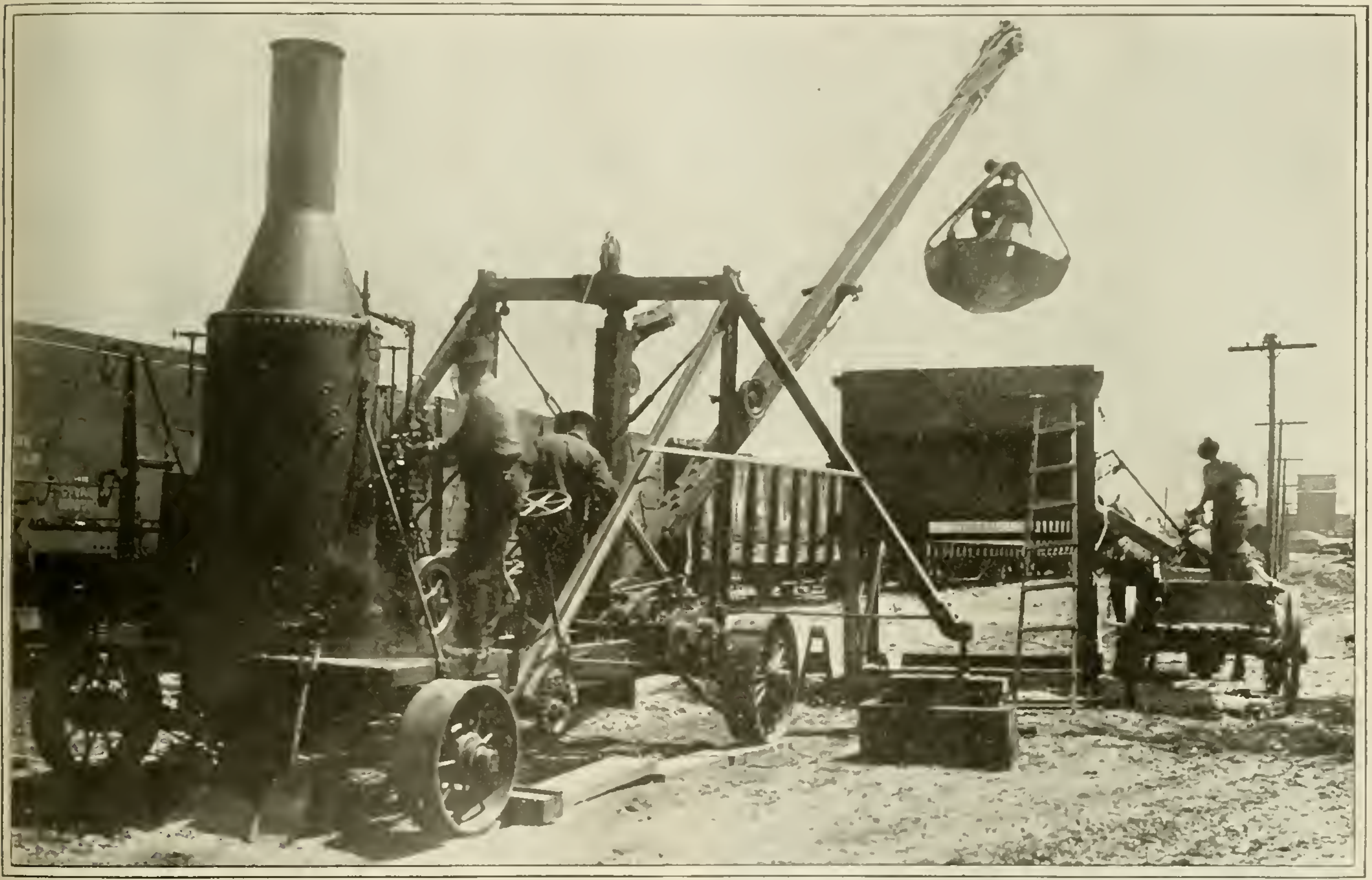
The engine is guaranteed to develop 18 H.P. by brake test; Byers heavy vertical marine type double cylinder; compound geared to hoist. Model A has two friction drums for bucket lines and a hand crab for changing boom radius; Model B has all three drums, live power friction drums. All drums have brakes, ratchets and pawls, steel drum barrels 11 in. diameter by 13 in. long; capacity, 4,000 lb. on single line. Boom swinger at front is equipped with two friction drums, driven by steel chain from main engine. Car spotting winch is regular with Model B, but extra with Model A. One man operates bucket swinger, boom, lift, traction and steering.

The boiler is 32 in. & 70 in. Byers hand made, can be furnished to comply with all local ordinances. All boilers pass Hartford specifications. We recommend steam as the most flexible power, but can furnish gasoline or electric power if conditions demand it.

The boom is 8 in. x 10 in. selected yellow pine or Oregon fir; heavy steel fittings both ends; three rod steel truss full length. On ordinary unloading work with boom at 45° length can safely be increased to 30 ft.

All sheaves 12 in.; have self-lubricating graphited bronze bushings. All wire rope ½ in. plow steel. Tag line to keep bucket from swinging; steel tiller rope with counterweight sliding in steel guides on A-frame.

Frequently customers have on hand or prefer to furnish the bucket themselves. For sand, gravel, screenings, small coal and similar loose material most any light standard bucket does well. But in 1-in., 2-in. or 3-in. crushed rock, slag and large dense interlocking materials, it is very important to have a high powered bucket and sometimes even the addition of teeth. Consequently it is very important to have a bucket adapted to the service, as otherwise results may be very disappointing. One-half yard is the proper size for clam shell; if necessary to use orange peel, use a 12-ft. bucket, as the orange peel is much heavier than the clam shell.



Auto Crane Excavator and Unloader.

## SOME RECORDS OF EXPERIENCE WITH TRENCH BACKFILLING MACHINES.

The illustrations selected from two jobs of trenching and the following account of work based on six years' experience on many jobs of power trench backfilling are from information furnished by the Moore-Sieg Construction Co., Waterloo, Iowa, contractors. The backfillers illustrated are machines of the type manufactured by the Waterloo Cement Machinery Corpn., Waterloo, Iowa. The experience of these contractors is that the power trench filler is one of the most valuable and useful machines used in trenching. In addition to filling, there are numerous uses to which the machine can be put. For example, Fig. 1, on work at Iowa Falls, Iowa, shows the backfiller operating a derrick to hoist rock from a deep trench. This same machine later backfilled the trenches. In Fig. 2 the machine is shown working in close quarters at Decorah, Iowa. Referring to this work, Mr. J. L. Bridges, superintendent for the contractors, writes as follows:

On Central Street and High Street we had about 1,500 ft. of ditch, 8 to 13½ ft. deep, 6 ft. wide at the top (necessary because blasting caused banks to cave), in nearly solid rock. We filled the 1,500 ft. with the double quick filler and two men in six days' time. About 300 ft. of this ditch had stood open from November to April, and I have never seen a team that could handle a scraper under these conditions. There has been considerable work in the alleys here and we have used this backfiller very successfully where it would have been impossible to use a team on account of the width of the alley, it being only 19 ft. between buildings. What I value the most is the fact that we have the filler on the job all the time, wasting no time waiting for a team, thereby keeping the ditches filled ahead of rain and keeping the streets open to traffic.

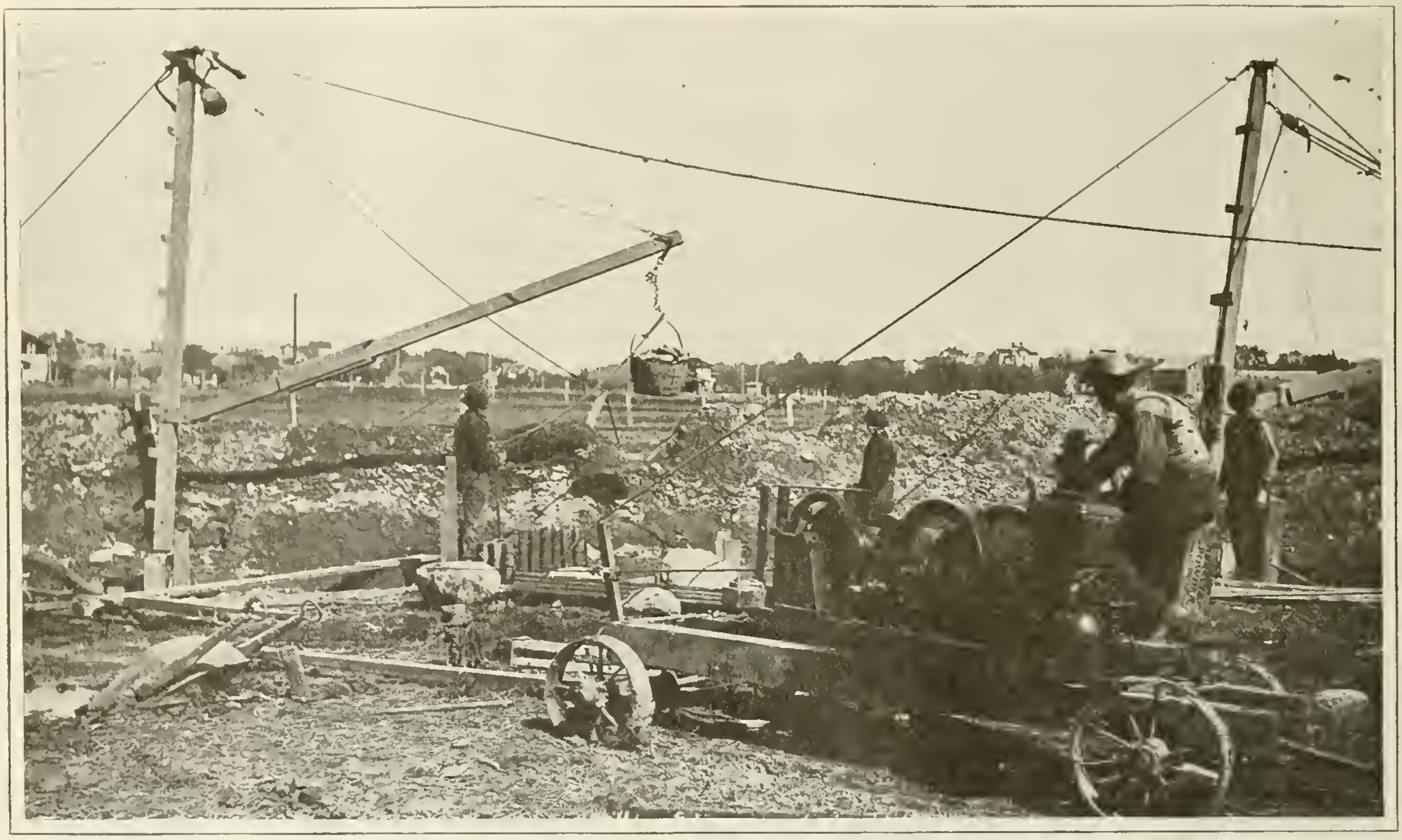


Fig. 1—Waterloo Trench Backfiller Operating Derrick for Hoisting Rock From Trench.

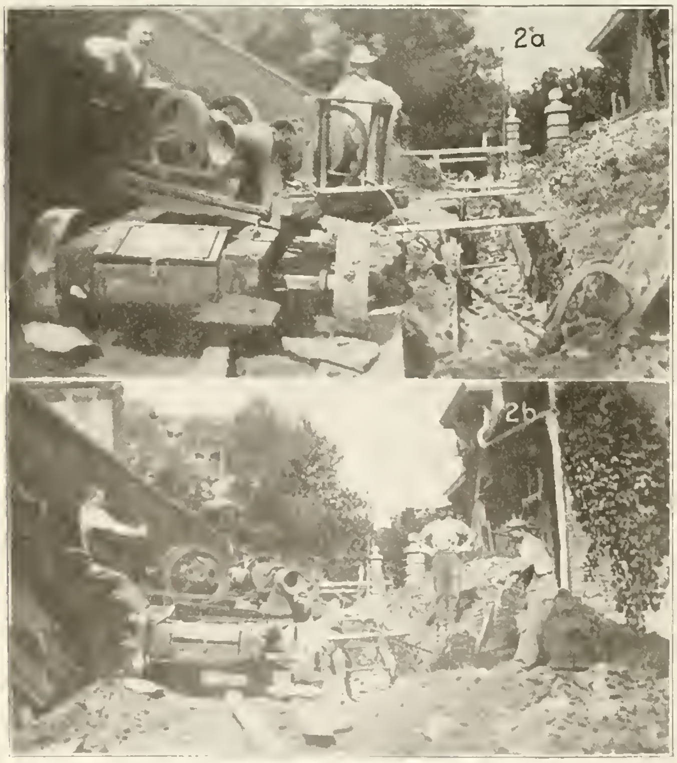


Fig. 2—Trench Backfiller Operating in Close Quarters at Decorah, Ia.

Top view shows engine skewed where narrow space prevents pull at right angles to machine. Bottom view shows rocky nature of spoil bank being worked on.

The contractors furnish the following other records and comments drawn from their experience:

On straight, clean work, where there is plenty of room and enough to keep a team busy steadily, the cost of backfilling by machine is approximately one-half of the cost of doing it by the team and scraper method. But on difficult work, and for short stretches where the team would not be available or would stand idle a part of the time, machine work costs from 10 to 40 per cent of team or hand work.

At Decorah, Ia., we used four machines, following two Austin trenches and five hand crews, the latter working largely in rock.

At Rockwell City, Ia., we laid 13,600 ft. of 4-in. water main in a 6-ft. trench in thirteen working days, using two trench fillers, at a cost of 1 ct. per foot for backfilling. The backfillers were hitched tandem following the trench machine.

In all difficult work it is absolutely essential that the hoist be mounted on a turntable so as to swing freely to the proper pulling angle. This makes it possible for the man with the scraper to "nurse" the rocks and hard places and accomplish the same work with a light, portable machine that would require an exceedingly heavy and large powered outfit of the rigid type. It has been our observation that there is a great tendency to make trench fillers too heavy, thereby destroying a large part of the economy in their use. We have tried out thoroughly the traction feature and have reached the conclusion that the additional weight, cost and complication more than offsets the occasional advantage such a machine offers.

## SOME RECORDS OF MOTOR TRUCK MINE HAULAGE COSTS AND EXPERIENCE.*

Two Alco 3½-ton motor trucks were used by Young Bros. while operating at the Mammoth Collins mine at Shultz, Ariz. One was equipped with an oil tank holding 1,075 gal. and was used for the transportation of "tops." The other was fitted with a stake body and used to carry machinery, wood, rails, pipe and all classes of miscellaneous supplies. The bodies were made of oak with maple flooring and were attached to the frame of the chassis by U-bolts, to avoid drilling the main members of the frame.

Most of the hauling was done from Tucson, a distance of 47½ miles. During the first three months, part of the road was in very bad condition and the tire cost was excessive. After this part was repaired the road was in fair condition, but never good. There were no excessive grades or bad sand, but wagon ruts, too narrow for the truck wheels and of a different gage, caused heavy tire loss; while chuck holes, sharp curves and stones, both imbedded and loose, were objectionable features. During wet weather the trucks could not get sufficient traction to climb some of the hills and were likely to stick in the mud in certain places, so that no attempt was made to run them unless they were on the road when the rain started. This lost time amounted to about 5 per cent of the total, but, whenever possible, it was utilized in making minor repairs.

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*Extract of a paper in Transactions, American Institute of Mining Engineers, by W. G. McBride, Long Beach, Cal.

The price of gasoline was from 17 to 21 ct. per gallon. Rubber tires were used throughout. Drivers were paid $4.50 to $5 per shift, and a return trip to Tucson was counted as two shifts even when made in one day. Drivers were provided with a room in Tucson and were paid for all time lost due to causes beyond their control. Trucks were loaded one way only.

Speedometers were placed on both trucks but the excessive vibration soon caused them to fail. For this reason, and because no account was taken of the distance covered in picking up a miscellaneous load or in other minor ways, the mileage given is under the actual distance traveled. Some of the weights had to be estimated, but care was taken to have the number of ton-miles low rather than high, to avoid underestimating the costs. The cost of hauling from Tucson to the mines was $12 per ton with the trucks, while the best possible team price was $15. Teams made one return trip a week, while the truck regularly made one in two days and could always, and many times did, do it in one day. The loss of time due to wet weather would be about half as much with teams as with trucks.

The table of detailed costs given below covered the period from Aug. 21, 1913, to Aug. 15, 1914, the only time in which the trucks were continuously employed. From Aug. 15, 1914, to March 30, 1916, the trucks were used intermittently, but the figures for this period have been excluded as not being representative. If included, they would somewhat lower the cost per ton-mile. Just prior to the close of the period covered by the cost figures, the trucks were overhauled and put in good condition; new rear wheels were put on and new tires secured. The cost of all this was charged to operation. Allowance for extra tires on hand would reduce the cost per ton-mile approximately ¾ ct., leaving a net cost of about 25 ct. With loads on the return trip this cost per ton-mile would be lowered at least 40 per cent.

MOTOR TRUCK OPERATING DATA.

| | |
|---|---|
| Total distance traveled by trucks | 23,000 miles |
| Total work done by trucks | 42,700 ton-miles |
| Average distance covered per gallon of gasoline | 4.5 miles |
| Average distance covered per gallons of lubricating oil | 128 miles |
| Average speed, loaded | 7 miles per hour |
| Average speed, light | 7.8 miles per hour |

DETAILS OF COST.

| | Per truck-mile. | Per ton-mile. |
|---|---|---|
| Wages of drivers | $0.1141 | $0.0614 |
| Wages of helpers | 0.0125 | 0.0067 |
| Repairs, labor | 0.0253 | 0.0136 |
| Repairs, lost time | 0.0068 | 0.0037 |
| Oils, grease and waste | 0.0165 | 0.0089 |
| Gasoline | 0.0700 | 0.0377 |
| Tires | 0.1063 | 0.0573 |
| New parts | 0.0224 | 0.0121 |
| Miscellaneous supplies | 0.0152 | 0.0082 |
| Incidental expense | 0.0098 | 0.0053 |
| Depreciation | 0 0781 | 0.0421 |
| Total | $0.4770 | $0.2570 |

The advantage of the motor truck over the team and wagon are many—increased speed, ability to work 24 hours per day when necessary, and lower cost on long hauls—but its adoption by the mining industry has been slow. Where trucks are used around mines they are usually driven by cheap, inexperienced men, the upkeep and repairs being turned over to the regular mine mechanics. It would be equally good practice to employ a timber framer to make a dining-room table. Just as the niceties of cabinet making are unknown to the timber framer, the exact adjustments and fine workmanship of the high-speed engine and transmission gears of a motor truck are beyond the ken of the mine machanic, one of the least skilled of his class. If there are enough motor vehicles at the mine, the master mechanic probably turns the work over to one or two men who, in time, become indifferent auto-mechanics, but in the meantime the cost of maintenance soars and often trucks are condemned. The aim of makers of all motor vehicles is to secure the maximum of strength and power with a minimum of weight and size. To do this, high-speed engines, the best of materials and the finest of workmanship are employed and parts are reduced to the least possible weight consistent with strength and durability. This is just the reverse of the ordinary American mechanical practice in which reliability is secured by slow speed and large size, the amount of material used and the space occupied being minor considerations. It is, therefore, unreasonable to expect the mechanic trained in one school to understand immediately and adapt himself to the ways of the other. It must also be remembered that no other machine is given the hard use and necessary abuse that a motor truck receives. The road vibration, alone, will loosen nuts and rivets which, if not attended to in time, will cause serious trouble. Where only one or two trucks are used, the drivers should be competent mechanics and should be held responsible for the maintenance of their machines. Where several are used, they should be under the direct supervision of a thorough truck mechanic who is held responsible for operation and given entire control of the drivers and repair work. His constant care will detect and remedy many incipient defects and prevent expensive and annoying breakdowns. With the exception of the time required for periodic overhauling, he should be able to keep the trucks in almost continuous service. This will make possible the employment of cheaper drivers without undue damage being done to the machines.

Motor trucks should not be installed without careful consideration of the roads to be traveled. The difference between the cost of motor truck and team hauling is largely controlled by the quality of the road, and on really bad roads the motor truck is decidedly the more expensive. Many roads are fatal to truck haulage, and considerable experience is required to decide this question without an actual test of some duration. Excessive grades are to be avoided, especially long ones. The ordinary truck will pull over a short 20 per cent grade with ease, but will give great trouble on a long one of half that rise unless special cooling arrangements are made. Grades greatly increase the tire and gasoline consumption and decrease the life of the machine. Rocky roads, particularly when the rocks are sharp or loose, are very hard on tires. Deep sand is difficult to cross, and for this class or road the caterpillar tractor and the four-wheel-drive truck have distinct advantages. Trucks which drive on the rear wheels only cannot operate in heavy sand. Narrow or rutted roads are objectionable for the larger-sized trucks because they throw all the weight on one of the rear dual tires from time to time, and this overloading is injurious to the rubber. Fairly deep streams can be crossed, but mud is an absolute barrier except to the caterpillar type of tractor. Few dirt roads will stand up under a 7-ton truck, but those of 4 tons, or under, do less damage than the ordinary freight wagon.

Unfortunately, trucks are not designed to suit mining conditions. At Shultz we found it necessary to cut down the gear ratio, increase the size of wheels and tires and add bumper or auxiliary springs. Had the grades been steeper it would have been necessary to increase the cooling capacity.

For long hauls the motor tractor will probably replace the motor truck. It will operate at a lower cost because the load will be carried on iron tires, and, as the table of detailed costs shows, the rubber tires account for 22.3 per cent of the total. Tractors travel more slowly than motor trucks, but the tonnage hauled in a trip is much greater. They are also easier on roads, as the load is distributed over several trailers. By using extra trailers, loading and unloading can be done while the tractor is on the road.

The make of a truck is not as important as the care it receives. Almost any standard make will do good work if given careful attention, but none will be satisfactory if not well cared for. Economy should not be sought in the lubricants used; the best oil is none too good for a motor truck. Overloading should be scrupulously avoided. A truck may be made to carry many times its rated load without breaking down but the damage is none the less real because not immediately apparent. High speed, particularly if the road is rough, should be avoided, since it subjects the machine to excessive strains and vibration. Most trucks are now equipped with speed governors, but these are easily tampered with and must be carefully watched. When they are not used, the drivers should be carefully instructed as to the speed limits and compelled to respect them.

Distillate and "tops" are now successfully used on trucks, by the application of a special carburetor. Their use should effect a material saving in the gasoline cost which now amounts to almost 15 per cent of the total. "Tops" usually sell for 30 to 35 per cent and distillate for 50 to 60 per cent of the price of gasoline. With a properly designed carburetor, the available power in the lower grade fuel will be about the same as in the gasoline, but the carbon deposition will probably be somewhat greater.

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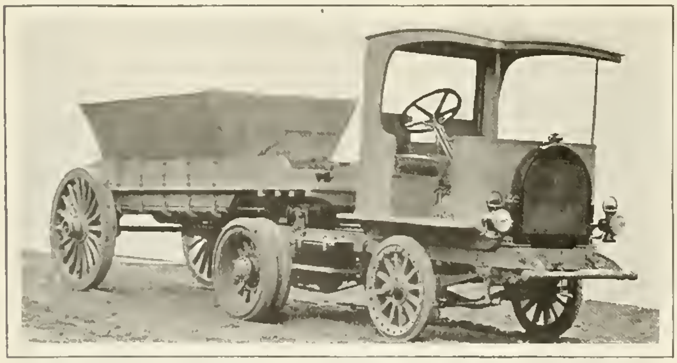
## A TRACTOR AND SEMI-TRAILER CONTRACTORS' HAULING OUTFIT.

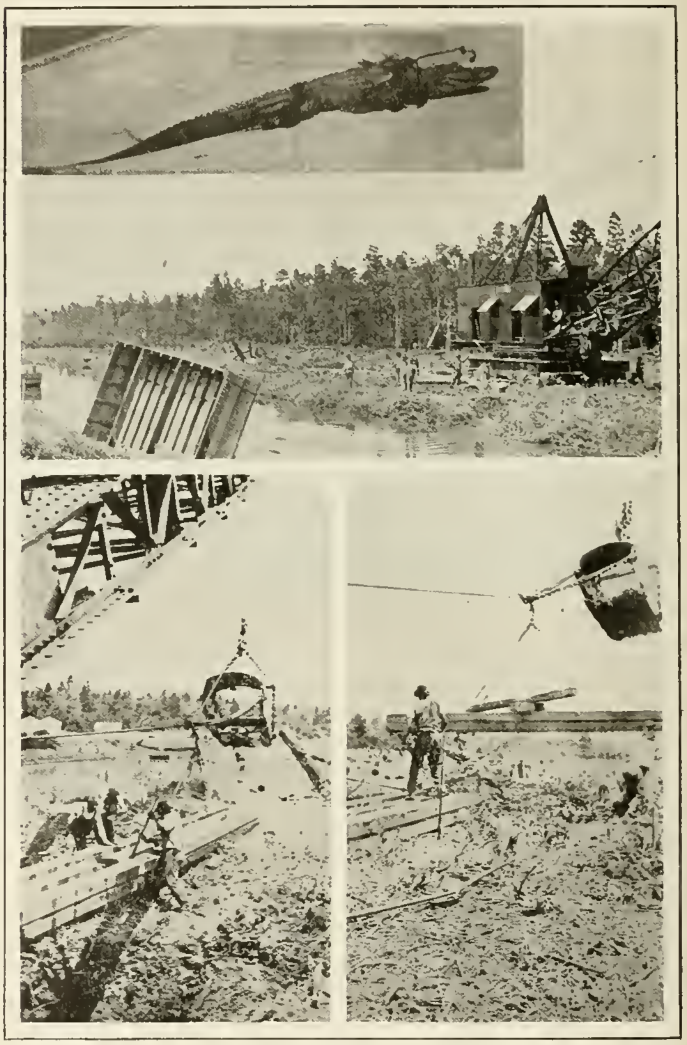
The illustration shows a tractor and trailer combination for contractors' hauling which has a number of special features. The trailer carries the load, about 70 per cent of the weight of which is on the rear steel-tired wheels and the tractor pulls the load. The trailer shown has a 120-cu. ft. dump body, but any special form of body required by the character of the load can be used. The trailer is quickly coupled and uncoupled and it is common practice to use three trailers with one tractor, one being loaded, one being hauled and one at destination being unloaded. Any other of several similar combinations of trailer and more than one trailer can be effected to suit the conditions. With the combination as shown by the illustration a turn can be made without backing in a 31-ft. circle and by backing the train can be turned in a 20-ft. street. The wheel base of the tractor is only 80 in., and that of the trailer is 11 ft. 3½ in. In addition to its short wheel base the tractor has the feature of an independent spring supported from plant sub-frame. None of the load comes on the springs of this sub-frame, but on the heavy springs of the main frame. There are two separate sets of springs, one set adjusted to the light constant load of the power plant, gasoline tank and driver's seat, and a second set for the tractor frame proper. The tractor hauling unit as illustrated has been tried out for a season on actual contract work and is marketed with full assurance by the builders of its efficiency. The builders are the Watson Wagon Co., Canastota, N. Y.



Tractor and Semi-Trailer Contractors' Hauling Outfit.

## TIMBER TRACKWAY UNITS FOR DRAG LINE EXCAVATORS.

The illustrations received from levee building work in the vicinity of New Orleans show besides a native of the locality an excavator trackway unit of which any contractor, according to D. W. O'Bannon, superintendent, D. B. Gore Co., should take notice. This trackway unit is made up as follows: Four 6x12-in x 20 ft. timbers are laid broadside down side by side and bolted together. On these is nailed a close decking of 2x12-in. cross planks. On the decking are placed three 6x12-in. x 20-ft. timbers as follows: Two outside timbers set laterally flush with the outside edges of the decking and longitudinally so as to project 18 in. at one end and recede 18 in. at the other end in respect to the ends of the decking; one middle timber set midway between the two outside timbers with one end projecting 24 in. and the other end receding 24 in. The three top timbers are bolted through to the lower timbers, binding the whole platform into a rigid unit. By means of the end construction described, it will be seen, the first end of one unit interlocks with the rear end of the succeeding unit to make a continuous trackway. By means of the spans between the top timbers "cutting" of the rollers on which the excavator rides the trackway is facilitated. A set of ring bolts in each unit permits the unit to be lifted and swung ahead by the excavator boom. In the work illustrated eight units were employed. The machine was a Class 20 Bucyrus drag line weighing about 100 tons; for heavier machines Mr. O'Bannon states that the units should be made wider. He also says that in the work illustrated the trackway never sunk to exceed 4 in. under load. The moving of a unit ahead and coupling it up



VIEWS OF DRAG LINE LEVEE WORK OF D. B. GORE CO., INC., NEW ORLEANS, LA.

A Native of the Country—Drag Line Excavator at Work—Coupling Up Trackway Units—Swinging Forward a Trackway Unit.

was done by the machine and four men in 8 to 10 minutes.

## HAMMER DRILL RECORDS AT THE FRANKLIN MINES, NEW JERSEY.*

The compressed-air rock drill made revolutionary changes in mining methods and in the reduction of mining costs in units of labor per ton of ore, and at Franklin even more marked savings have been made through the development of hammer drills. There, in the days of hand drilling, a total of 8 ft. in three drill holes with varying diameters of 1¾ to 1¼ in. was considered a fair 10-hour shift's work, and possibly 8 tons of ore would be broken per drill-shift or 4 tons per man-shift. With 3-in. reciprocating rock drills from 20 to 40 ft. of drill holes, ranging in diameter from 2½ to 1½ in., would be the average work for a 10-hour shift, although on rare occasions some men might drill as much as 80 or 90 ft. of holes in a shift, and possibly 20 tons of ore would be broken per shift, or 10 tons per man-shift, since two men were needed on a drill. It seems that as a rule a greater tonnage per foot of hole was obtained with hand drilling because of the fact that, rather than dismount and reset heavy drill columns, machine men would tend to place as many holes as possible from one set-up, therefore many holes were placed disadvantageously for breaking efficiency. Another cause, which would contribute to the same results, would be the difficulty of starting holes with piston drills on uneven sloping faces, so that holes were frequently deflected from the direction in which they were supposed to be placed. These figures would lead to the rough estimate that 2½ times as much tonnage per drilling man-shift was accomplished by piston drills as by hand drilling.

With hammer drills 80 to 100 ft. of 1¾ to 1¼-in. drill holes are placed by one man in a 10-hour shift, about 150 to 200 tons of ore will be broken per drill-shift and the same amount per drilling man-shift, or 15 to 20 times the amount broken per man with reciprocating drills. Of course, the entire credit for such increase in tonnage cannot be given to the type of drill, for improved organization, system of working, and supervision have undoubtedly played an important part; but the greater mobility and flexibility of the light hammer drills have permitted and encouraged a more efficient placing of drill holes; have cut in half the labor necessary to run a drill; and permitted a more effective supervision and mining scheme.

**Drifting.**—There have been no radical changes in the placing of the drill holes in drifts since the adoption of the air-feed hammer drill for this work, but one man with a single machine is now placed in a heading; he is instructed to "pull" a "round" each 8-hour shift, stopping overtime if necessary, and to accomplish an advance of 3½ to 4 ft. per round. Two men operating a reciprocating rock drill formerly made an advance of a 5 to 6-ft. round in five 10-hour shifts. So the drilling labor (runners and helpers) per foot of advance averages 18.4 hours for the entire mine during the year 1910, when reciprocating rock drills were solely in use. As shown by the average for 1913, hammer drills have reduced this figure to 5.3 hours per foot of advance, or about one-third the former labor of drilling and blasting. The explosive costs have also been reduced by the use of hammer drills from the figure of $1.84 per foot of drift during 1910 to $1.40 per foot in 1913, for two probable reasons.

First, hammer drills permit the placing of drill holes smaller in diameter than those bored by reciprocating drills, so that an unnecessary amount of explosive is not required merely to fill the holes sufficiently to distribute the force of the explosion.

Second, the flexibility and ease of rigging the light hammer drills permit and encourage a more efficient placing of drill holes. The almost exclusive use of 1 by 8-in. explosive cartridges now, as contrasted with the 1⅛ by 8-in. cartridges formerly used, demonstrates the first contention, for in terms of 1-in. powder, the equivalent of 36.8 sticks per foot of drift was used in 1910, and 34.6 sticks per foot in 1913. The drill shifts per foot of advance have been lowered from 0.74 in 1910 to 0.33 in 1913, and the corresponding drill hours from 7.4 to 3.0.

The different drifts may vary in size from 6 by 7 ft. to 8 by 11 ft. in section, and perhaps 7 by 8 ft. is an average section. Because of the compact, tough nature of the ground, it requires from 20 to 30 drill holes in a round, and 24 would be a fair average, so the drilling operation is an important factor of the drifting costs. The following comparison of the average drifting costs for each year shows the saving which has been possible because of hammer drills; but only the cost of drilling labor and explosives is considered. The record drift in 1913 was driven for $2.06 per foot.

| | 1910. | 1911. | 1912. | 1913. |
|---|---|---|---|---|
| Drifting cost per foot................ | $5.33 | $4.92 | $3.35 | $2.70 |

**Raising.**—In 1908, using 2¼-in. piston reciprocating rock drills, 0.7 ft. of 6 by 6 ft. raise per 10-hour drill shift was made with a labor expense of 28.5 man-hours per foot of raise. About 27 ft. of drill holes were placed per shift, 24 holes were placed in a round, and 16 lb. of explosives were used per foot of raise advance, at a cost of $2.70 per foot for supplies. Since labor was then paid $2 and $1.55 per 10-hour shift, the total cost of raising was approximately $7.50 per foot of advance.

During the same year, 1908, hammer drills were introduced, and an advance of about 1.5 ft. per drill-shift was made with a labor expense of 13.3 man-hours per foot of advance. About 50 ft. of drill holes were placed per shift, 24 holes per 5-ft. round, and 10 lb. of explosives were used per foot of advance, at a cost of $1.75 per foot for supplies and a total cost of $4.10 per foot of raise, or only 55 per cent of the cost with the reciprocating rock drills.

The development of hammer drills with increased drilling speed permitted the reduction of the drilling labor to 7.8 hours per foot of raise advance, and the explosives cost to $1.54 per foot of raising done in the year 1910; and a further reduction of 4.8 hours of drilling labor during 1912, and an explosive cost of $0.93 per foot, although the wages were $2.20 and $1.70 per 10-hour shift. These costs rose slightly in 1913, since wages rose to $2.25 and $1.85 for 10-hour shifts, and in July of the same year the working hours were lessened from 10 to 8 and the hourly wage was increased to $0.281 and $0.231. However, the cost per foot was then only 5.2 hours of drilling labor and $1.03 per foot for explosives. Amout 18 drill holes are now placed to pull a 5-ft. round and two men are expected to blast a round each 8-hour shift and are each paid 11 hours' time for performing the task.

The average raising costs for operating labor and explosives have been as follows:

| | 1910. | 1911. | 1912. | 1913. |
|---|---|---|---|---|
| Raising cost per foot................ | $2.95 | $2.31 | $1.88 | $2.22 |

The record short raise (of about 50 ft. in length) for 1913 had a cost of $1.65 per foot, and the record long raise (about 100 ft. long) had a cost of $2.09 per foot, with explosive costs, respectively, of $0.77 and $0.99 per foot of raise.

**Stoping.**—In 1909, when about 74 per cent of those drills placing holes in the solid ore body were of the reciprocating type of 3-in. piston diameter, the ore production averaged about 20 net tons of ore broken from the solid per 10-hour drill shift, with an equivalent of 1.1 sticks of 1 by 8 in. of 50 per cent dynamite per ton of ore.

In 1910, when about 72 per cent of the producing drills were air-feed stoping (hammer) drills, the tonnage per drill shift rose to 38 net tons with about the same amount of explosives (which cost $0.055 per net ton of ore broken), and 13.2 tons were broken per 10-hour shift of men working in stopes, or 1.32 tons per hour. Although there is no record of the breaking labor prior to this year, the fact remains that in the actual running of the drills only one man was used with a hammer drill while two men were employed with each reciprocating drill.

In 1911, when the hammer drills were about 80 per cent of the total, the stoping efficiency profited by the improvements in the drilling speed of the hammer drills, and 121 net tons were broken from the solid per drill-shift with about 0.8 stick of 50 per cent 1 by 8 in. dynamite per ton (at an explosive cost of $0.041 per ton), and 2.03 net tons were broken per man-hour of men working in stopes.

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*Extracts from a paper before the Institute of Mining Engineers, by B. F. Tillson, Franklin Furnace, N. J.

In 1912, when about 98 per cent of the stoping drills were hammer drills, 195 net tons were broken per drill-shift with about 0.87 stick of 50 per cent 1 by 8 in. dynamite per ton (at an explosive cost of $0.045 per ton, and at the rate of 2.56 net tons per man-hour in the stopes.

In 1913, when all the stoping drills were hammer drills, the length of the working shift was reduced from 10 to 8 hr. in the middle of the year and the tonnage broken per drill-shift fell proportionately to 170 net tons, but remained at approximately the same hourly rating as for the year 1912. However, the tonnage broken per man-shift in the stopes increased slightly to 26.7 net tons (at an explosive cost of $0.049 per ton, with the consumption of 0.89 stick of 50 per cent 1 by 8 in. dynamite per ton. The tonnage broken per man-hour was 2.97, which showed a steady gain over previous years.

It should be noted that the explosives charged against stoping include those used by the trammers in blasting ore in the chutes, and thus represent all the dynamite necessary to reduce the ore to the proper size for being handled through chutes and in the mill.

**Opencut.**—In order to provide broken rock for filling material to fill empty stopes to support the remaining ore-body, "mill-holes" are developed in limestone country rock at the surface. For some years it was the practice to use 30-ft. bench-holes in the opencut for quarrying the rock, both 3-in. and 3½-in. reciprocating rock drills being used. It took steady work for two men to sink one 30-ft. hole in a 10-hr. shift, and their work was hazardous because of the inconvenient localities where set-ups were made, and because of the clumsy weight of their machines and the long, heavy drill steels which were handled. After the success of hammer drills in the underground mining operations, they were tried in the opencut work in 1912. Small holes were drilled to an average depth of 16 ft., and were given lighter burdens than had previously been the practice, for the object was to distribute the dynamite more evenly in the rock, as contrasted to churn-drill or mammoth blasts. In the tough, crystalline Franklin limestone this application of hammer drills to quarrying has proved superior to the heavy or mammoth blasts, for the same tonnage can be produced from a bench with a saving of labor and powder, since a great amount of expensive block-holing is avoided. A machine will drill about 100 ft. of holes in a shift with a heavy hammer drill and two men can drill only 30 ft. with a rock drill.

## A $3,750,000 WATER SUPPLY PROJECT.

The Rand Water Board of Johannesburg, South Africa, is to carry out a modified scheme for the extension of the water supply for Johannesburg and the outlying districts. This provides for the erection at Lindeques of the barrage as originally designed. The barrage will be composed of 36 gates, each 25 ft. high and having a span of 30 ft. It will impound altogether 13,633,000,000 gal., of which the board will be at liberty to abstract annually 7,300,000,000 gal., or 20,000,000 gal. per day. The estimated cost of the whole scheme is $3,751,308, but this includes pipes to the present value of about $63,265 now in stock, which, deducted from the first figures, reduces the actual amount of cash required to complete the scheme to approximately $3,688,043. Of that amount about $204,393 has already been expended on preliminary surveys, the collection of data, legal and parliamentary expenses, the erection of weirs, and other minor works classified under the head of preliminary expenses. The chief engineer estimates that the whole scheme can be completed, and water from it brought into service, in three years from the date on which the construction work is actually commenced.

The following is a summary of the estimates prepared by the chief engineer, showing the cost of the scheme under certain main headings, but exclusive of interest on cost during construction:

| | |
|---|---|
| Barrage, measuring weirs, etc | $1,124,400 |
| River pumping sation, Vereeniging, including intake | 43,798 |
| Main pumping station, Vereeniging | 291,990 |
| Quarters for men, Vereeniging | 29,199 |
| Sundry station buildings, Vereeniging | 19,466 |
| Precipitation tanks, filters, and sterilinzing plant | 267,657 |
| Service reservoirs and basin | 194,660 |
| Laying out ground, boundary walls, etc | 19,466 |
| Railway siding, Vereeniging | 7,300 |
| Pipe lines | 1,085,775 |
| Extensions and new plant at Zwartkopjes station | 158,161 |
| Telephone lines | 19,466 |
| Land, wayleaves and legal expenses | 224,054 |
| Expenditures and preliminary expenses | 204,393 |

## NEWS LETTERS.

### St. Louis Items.

The L. J. Smith Construction Co., 1116 Commerce building, Kansas City, Mo., has a few miles of nice team work on the Missouri, Kansas & Texas R. R. to sublet. Free transportation for outfits and labor over the Katy R. R., north of the Texas line.

City Clerk G. H. Beineke of Belleville, Ill., received a letter from officials of the Louisville & Nashville Railroad stating a modern brick station will be erected in Belleville. William Savage, Belleville's agent, said he understood plans have been drawn. The City Council recently passed an ordinance condemning the present station as unfit for human use.

J. I. Gedney of East St. Louis has been awarded the contract to build the new school house at Woodriver, Ill. His bid was $18,248.

Contracts for work on state aid roads in St. Clair County will be let by the Illinois State Highway Commission at Springfield, August 23, County Superintendent of Highways D. O. Thomas at Belleville announced last week.

The Fred M. Crane Company of Omaha, Neb., were low bidders on the big levee job across the river here on July 25. Up to the present writing work has not been awarded.

An ordinance providing for the construction of a sewerage system in the Winstanley district was passed last week by the East St. Louis City Council. Property owners have urged the building of the sewer for several years. It will cost approximately $430,000. The council unanimously passed an ordinance calling for the repaving of Missouri avenue from the Relay Depot east to Tenth street. Several streets are in a deplorable condition. It is thought they may be repaired with a new paving process successfully used in Jacksonville, Ill. Mayor Mollman and a party of city officials will go to Jacksonville to inspect the streets on which the substitute has been used.

C. M. Erganbright, Jr., Judsonia, Ark., has 150,000 yards of work on the Little Red River to sublet. Work to be completed within four months.

Ralph P. Taylor, Texarkana, Ark., can use a few team outfits on county road work in that neighborhood.

Sheahan Bros. have sublet 35,000 yards of Chicago & Eastern Illinois R. R. work to J. G. Berger of Fort Branch, Ind. Mr. Berger is moving a 28-team outfit on to this job.

C. C. Aderholdt has 80,000 yards of levee enlargement work near Linda Landing, Mo., to sublet. Address him care of Kaiserhof Hotel, Denver, Colo., or J. F. Maloney, 6310 Olive street road.

Contractors wanting work for their outfits get in touch with Koenig's Labor Agency, 612 Walnut street, St. Louis, Mo., or 503 Delaware street, Kansas City, Mo.

S. D. Tripp has moved his outfit onto a part of the L. J. Smith Construction Co.'s work on the Missouri, Kansas & Texas R. R. in Oklahoma.

W. E. Callahan Construction Co. of Omaha are moving one of their drag lines on the Alton Southern R. R. near East St. Louis. They have ten acres of clearing on this job that they want to sublet. Will pay $75 per acre for it. This company also secured nineteen miles of line changing on the Evansville & Indiana R. R. near Terre Haute, Ind. Have 60,000 yards of team work and 6,000 yards of side hill rock work to sublet on this job.

P. J. Murphy, the popular Wabash contractor, was married to Miss Julia Holland the other day. Mr. and Mrs. Murphy are spending their honeymoon in Chicago. The boys at Moberly are anxiously awaiting their return.

M. D. Murphy, a brother of P. J., returned from Sparta, Ill., where his daughter has been quite ill with typhoid fever. At the present time Mr. Murphy is at work on the Wabash R. R. at Carrollton, Mo.

A. B. KOENIG.

## PERSONALS.

A. M. Valze, head of the A. M. Valze & Son, railroad contractors, died July 22, at Baltimore, Md.

Charles D. Sneed, bridge engineer for the Virginia Highway Commission, has been appointed bridge engineer of the Road Commission of Kentucky.

D. Y. Swaty has been made vice-president of the Cleveland Engineering Construction Co., of Cleveland, O. Mr. Swaty formerly was construction engineer of the Great Lakes Dredge & Dock Co.

Joseph E. Love has resigned as engineer for the South Dakota Railroad Commission and is now connected with the engineering department of the Chicago Union Station Company, Chicago, Ill.

J. C. Watts has resigned his position as deputy city engineer of Troy, N. Y., to become engineer of the Harbor and Dock Commission of that city. F. X. Bode succeeds Mr. Watts as deputy city engineer.

W. F. Vale has been appointed superintendent of water works for the City of Santa Monica, Cal. Previous to this Mr. Vale was chief engineer and general superintendent of the Santa Monica Water Co., which is now owned by the city.

L. G. Wallis, heretofore resident engineer of the Southern Railway at Spartanburg, S. C., has been appointed engineer of construction for the Jacksonville Terminal Co., Jacksonville, Fla., and will have charge of the erection of the new union station in that city.

Austin B. Fletcher, state highway engineer of California, has been granted a furlough of a month and a half, during which time he will assist the federal government in organizing the work of the new road bureau to handle the $75,000,000 good roads appropriation.

Roy M. Green has been appointed assistant assessor of highway engineering of the Agricultural and Mechanical College of Texas. Mr. Green is a graduate of the University of Nebraska and has recently completed the graduate course in highway engineering at Columbia University. Since graduation he has been employed as testing engineer and superintendent of paving construction with Clark E. Mickey, consulting engineer, of Lincoln, Nebr. Mr. Green's appointment increases the highway engineering capacity of the college to three members. He will be in charge of the road laboratory.

Buildings and Structural Monthly Issue

Engineering and Contracting

Halbert P. Gillette, *President and Editor*

Volume XLVI. — CHICAGO, ILL., AUGUST 23, 1916. Number 8.

## IS THERE ROOM FOR A STRUCTURAL ENGINEERING SOCIETY?

Following an editorial in our last Building and Structural Monthly issue, July 26, we have received several letters approving the suggestion that an American Society of Structural Engineers should be organized. One subscriber asks how many members may be expected to join such a society at its inception and to how large a membership it may aspire ten years after its organization?

We believe it possible to secure an initial membership of 500 to 1,000, and that within ten years a membership of 20,000 may be obtained, provided the dues are not high and provided there are not too many restrictive conditions as to membership. Within a period of time closely comparable to this the National Electric Light Association has attained a membership of 14,000. That society has almost twice as many members as the American Institute of Electrical Engineers, although it is a great deal younger. Its transactions contain matter of much worth, and it has done an inestimable service in building up the electrical industry.

There is, we believe, a greater field for the development of the right sort of a structural engineering society than there was for the development of the National Electric Light Association. Consider the fact that there are fully 2,000,000 men engaged in the building industry, and that the vast majority of them are working without any engineering supervision, direct or indirect. Consider, further, that engineering of as high an order is involved in the economic design and erection of a building as of a bridge. Then ask yourself whether or not there is need for a society of structural engineers and room for its development.

## HIGHWAY OVERFLOW BRIDGE CONSTRUCTION IN THE TEXAS BOTTOMS.

About twenty years ago, in Queensland, Australian engineers begun building frequently a type of bridge involving a new idea in the solution of flood water problems. Instead of seeking above all things clearance for abnormal flow by keeping the bridge high and by multiplying span openings, the structure was designed deliberately, beyond certain reasonable waterway provisions, as an obstacle which floods must overtop and pass as they would an overflow dam. This plan meant obviously the disuse of the bridge during major floods, but under the conditions such periodic interruption of traffic was less costly than was insurance against traffic interruption by providing structures abnormally high and long. The overflow or low level bridge became common in Australian practice, and the older bridge engineers now practicing will recall its description and interested discussion before the British Institution of Civil Engineers by Mr. A. B. Brady, the designer of important structures of the type including the notable reinforced concrete arch bridge at Maryborough, Queensland.

The overflow bridge is an extraordinary design of bridge. Conditions have not been common which demanded its construction. In America it has been almost unrepresented. The reason does not lie in lack of localities where such bridges are logical structures. There are many such localities in the miles of overflow bottom lands of our Mississippi valley and Gulf coast states. The reason has been that until recently permanent bridge building has been very largely railway bridge building and the first rule of railway flood protection construction is to build above or beyond flood danger. The overflow bridge is almost inconceivable as a railway bridge type. As a highway bridge type it is a most logical structure, and as a highway bridge type we venture to prophesy for it extensive adoption as our bottom land country roads are improved and made permanent. That it has not been used in the past is because permanent highways and highway structures have been unconsidered things in this overflow bottom land territory.

An example in substantiation of the argument that the overflow bridge naturally suggests itself as a logical solution of flood land conditions is presented on another page of this issue. This article describes overflow highway bridge construction in McLennan County, Texas. It is to our minds one of the most suggestive contributions on highway bridge construction that has been offered engineers for a long time. To repeat any portion of this description here would be unfair to the reader; he should read the article thoroughly. If he does and studies the illustrations carefully he will, we believe, support our conviction that in the overflow bridge of concrete, flanked on each approach by concrete armored roadway, the highway engineer has a most useful structural form.

## THE U. S. CENSUS OF THE BUILDING TRADES AND ITS SIGNIFICANCE TO STRUCTURAL ENGINEERS.

Although the census classification of the building trades leaves a good deal to be desired, it is possible to derive some very significant information from the statistics for 1910.

The number of architects is 16,613 and the number of civil engineers and surveyors is 52,033. In the 1910 census no segregation of surveyors from engineers is made, but in the 1900 census a segregation was made, from which it may be deduced that about 12,000 of the 52,033 are surveyors. How many of the 40,000 civil engineers are engaged in building designing is not stated.

There are 33,314 draftsmen, but no segregation is made between architectural draftsmen and engineering draftsmen.

There are 174,422 builders and building contractors, but here again there is no segregation between contractors for buildings and contractors for engineering works. It is probable, however, that not more than 25 per cent of this number are engineering contractors.

There are 7,064 foremen of road and street work, but the number of foremen of building work is not given separately.

The following are the numbers assigned to each of the classes of skilled workmen in the building trades:

| | |
|---|---:|
| Carpenters | 817,120 |
| Masons, brick and stone | 169,402 |
| Stone cutters | 35,731 |
| Structural iron workers | 11,427 |
| Roofers and slaters | 14,078 |
| Plasterers | 47,682 |
| Painters | 273,441 |
| Paper hangers | 25,577 |
| Total skilled workmen | 1,394,458 |

In addition to these there are 934,909 "laborers in building and hand trades," but no segregation is made of those in the building trades only.

From the foregoing facts it may be inferred that fully

2,000,000 men were engaged directly in erecting and repairing buildings in 1910.

The number of men classed as "structural iron workers" is strikingly small, and 40 per cent of this 11,427 reside in two cities—New York and Chicago. New York has 3,355 and Chicago has 1,166. In contrast with this is the fact that only 8 per cent of the carpenters and 13 per cent of the masons live in those two cities.

The extensive use of lumber for building is significantly brought out by the fact that nearly 60 per cent of the skilled workmen are carpenters and 20 per cent are painters. Hence about 80 per cent of all the skilled workmen in the building trades are engaged in framing, erecting and painting woodwork.

America has evidently barely entered upon an era of fireproof building construction. To structural engineers this is a fact of great import, for it makes it evident that an enormous undeveloped field lies before them. Coincident with the growth in general wealth there is an awakening to the fact that concrete, tile, brick, stone and steel can be so used as to produce fireproof buildings almost as cheap in first cost as those made mostly of wood. But even were the first cost considerably greater, the larger income of the average American would lead inevitably to the construction of better buildings of all classes—residential as well as industrial and commercial.

## CONCRETE FOR SALE.

Concrete is the only building material of major volume which is manufactured at the place of construction. This is true whether the consumption is large or small. For the basement of a small dwelling and for the walks that lead to its door concrete is manufactured at the place used. The cement, the sand, the stone are hauled to this place, stored and rehandled to the mixer or mixing board. Mixing boards and tools or a mixer and a mixing gang are required for each concrete job, however small. One cannot travel far about any city where building is active without being impressed by this multiplicity of concrete manufacturing plants. Often two small buildings side by side are observed under construction by different contractors, each with his individual plant for concrete making. There is waste of effort in such conditions which one is bound to feel should be eliminated, but how eliminated one is puzzled to decide. Yet the problem deserves thought.

Not long ago the editor paid a visit to an industrial town in process of construction. The buildings were mostly of brick and timber, with concrete basements and walks. Adjacent to the town limits on one side was a clay pit and here the contractor had a brick yard and was making all of the coarse bricks being used. In another direction and not much further from the town center was a gravel pit, from which the contractor was taking sand and gravel for his mortar and concrete. In the town were perhaps two score buildings in process of construction; there were more buildings recently completed and others "laid out" to be begun as time went on. In front of each building under construction was a stack of brick, being added to as need arose by teams from the brick yard. In front of each building, also, was a mixing board, or in case of buildings of size a concrete mixer—two-score perhaps of small plants and organizations for manufacturing concrete and mortar. To the visitor contemplating these very familiar conditions the question came: Why not at the gravel pit make concrete and mortar as bricks were being made at the clay pit and haul this concrete and mortar as the bricks were being hauled to the places where they were needed? The contractor's foreman had no answer to the query, and the editor came back to the city and his desk with the question still urging him for a reply.

Now the conditions in most growing cities are closely parallel to those in this small town being created anew where just recently there had been bare prairie land. On buildings, walks, sewers, pavements, mortar and concrete are being used somewhere in some amount on almost every block. The brick or tile or steel or timber being used on these works are ordered as wanted from the factory or dealers' yards. Why should not concrete and mortar be similarly obtainable? Why shouldn't concrete and mortar be "for sale"? They never have been, we know. It would be necessary, we also know, to educate users into the practice of buying them. This training should not be difficult. We have scant precedent for commercial purveying of concrete, but such as we have encourages belief in its possibilities. At Baltimore in 1915 concrete was sold delivered by the Building Supplies Corporation and the business was a success in attracting customers, though hampered by inadequate finances. The technical obstacles to be overcome would seem to forebode more trouble than any others.

As construction operations prevail on most small works concreting is an intermittent operation. Now concrete and mortar, unlike brick and I-beams, must be consumed as delivered. Delivery cannot be intermittent and irregular in varying quantities and be also economical. Successful use of purchased concrete, therefore, demands a reclassification or rescheduling of construction operations in such manner that concreting becomes as nearly as may be a separate continuous operation. There are very few constructions on which such a rearrangement is not practicable. The next question arising is: Can concrete be delivered without deterioration from a central plant over a wide enough area to be commercially successful? At Baltimore on city work supplied with concrete by the corporation previously named a limit of 30 minutes was set as the maximum time between mixing and delivery of the mixed concrete. Motor truck speeds range from eight to ten miles per hour for two-ton trucks. With a clear road on paved streets a motor truck can deliver within a radius of say four miles in 30 minutes. Cut off 50 per cent, due to traffic hindrances, and the circle within which motor trucks can deliver concrete 30 minutes after mixing is four miles in diameter.

To proceed with further analysis seems unnecessary. The leading thought in mind has been opened out sufficiently to make it plain. We believe that careful study of the conditions will demonstrate that Concrete For Sale is an entirely practicable accomplishment in any city of size where engineering and building construction is active.

## BUILDING CONTRACTING AS A FIELD FOR ENGINEERS.

When a civil engineer considers entering the business of contracting he is apt to select the building of roads, sewers, water works, and other "public works." Probably this is largely due to the fact that most "public works" contracts are let to "the lowest responsible bidder," which usually means to any one who can furnish the required bond. The construction of most buildings, on the other hand, is done under private contract, and the contractors are usually invited to bid. Such invitations naturally do not come to builders who are beginners.

While it may not be so easy a thing to get a start as a building contractor, we are of the opinion that this class of contracting today offers excellent opportunities for civil engineers who have managerial ability. To begin with, the risks involved in building contracting are ordinarily less than those in "public works," and "public utilities" contracting. This is made evident by the fact that there are more wealthy building contractors than wealthy public works contractors.

It is easy to start building contracting on a small scale. There is a vast amount of building work that is subcontracted by large general contractors to small specialists. Hence the simplest way of entering the field is as a subscontractor. Several engineers known to us have started as builders by purchasing small steam shovels for excavating basements. Others have begun as subcontractors for building foundations.

Already there is a goodly number of engineers engaged in erecting reinforced concrete mills and factories, and the number is increasing. But, attractive as that type of building is to the engineering contractor, there is really no sound reason why engineers should not undertake the erection of buildings of every class and size.

## "STRUCTURAL ENGINEERS WORK FOR ARCHITECTS."

A few months ago the editor received a visit from an Australian engineer in America to study building construction. "I am calling on Chicago structural engineers, or more properly, Chicago architects," he said. "I find that all your structural engineers work for architects." Now the structural engineers of Chicago do not all work for architects, but enough of them are so employed to excuse the conclusion by a visiting stranger that the practice is universal. And in this respect Chicago practice fairly represents practice in the United States. Actually as well as in the opinion of the public, the architect is the principal in building construction and the engineer is the subordinate. And it counts little to the benefit of engineering that its practitioners themselves know that modern building construction and design are essentially engineers' work.

Let us illustrate again. Two days before this writing the editor was conversing with a friend—a physician of broad intelligence. Said the physician, pointing to a new tall building: "That is a marvelous structure. It is just as much a great piece of engineering as is Brooklyn Bridge." "Very true," said the editor, "who was the engineer?" The answer was: "I haven't the slightest notion. Smith-Williams was the architect. I suppose the engineer was one of his men." The editor knows who Smith-Williams' engineer is, for it is a part of his duty to know such things. So do many Chicago architects and engineers and building contractors know this man and esteem his professional work; it is their business to know. But how many, whose occupation does not make this knowledge essential, have it. The editor's physician friend did not, yet he did know that Smith-Williams was the architect. And there are many others no more concerned personally who have learned the architect's name and remember it. And moreover if any of these men happens in the future to require a building to be designed and constructed he will think of Smith-Williams.

We therefore repeat: It counts little to the benefit of engineering that its practitioners know that modern building construction and design are essentially the tasks of the structural engineer. To count much this knowledge must be had by the merchant, the financier, the physician, the lawyer as he now has knowledge of the architect. These men must know the engineer as the principal, not as one of the architect's employes, and if they are to know the engineer in this way engineers must take concerted action to force the knowledge on them. The position of the architect is fortified by precedent, but this is not the whole reason why he maintains it so firmly. He has organized his profession for concerted action to a degree of strength nowhere approached by organizations of engineers. To combat organized architects, structural engineers must organize. They must organize as structural engineers. The interests of an organization of civil engineers in general are too diversified to permit forceful concentration of effort in promoting the interests of civil engineers specializing in structural work. The interests of restricted organizations like a society of railway engineers of bridges and buildings are too limited and individual to promise forceful work by them. Engineering and Contracting proposes that an American Society of Structural Engineers be organized.

## NINETEEN ENGINEERING SOCIETIES, 52,677 MEMBERS, TO BE HOUSED IN ONE BUILDING.

Upon the announcement June 27 that the American Society of Civil Engineers, by a vote of six to one, had decided to move into the Engineering Societies' Building, several engineering papers made the editorial statement that this would bring together about 30,000 members of technical societies. As a matter of fact, the number is already nearly twice 30,000 and will probably be 60,000 before the completion of the three-story addition to the building for the accommodation of the civil engineers and their library.

The following is the membership of all the societies that will occupy the building donated by Andrew Carnegie ten years ago:

| | |
|---|---|
| American Society of Civil Engineers | 8,022 |
| American Institute of Electrical Engineers | 8,308 |
| American Institute of Mining Engineers | 5,597 |
| The American Society of Mechanical Engineers | 7,149 |
| Aeronautical Society of America | 200 |
| American Society of Heating and Ventilating Engineers | 705 |
| American Gas Institute | 1,530 |
| Association of Edison Illuminating Companies | 73 |
| American Institute of Aeronautical Engineers | 121 |
| Empire Gas and Electric Association | 115 |
| Illuminating Engineering Society | 1,350 |
| Municipal Engineers of the City of New York | 600 |
| National Electric Light Association | 14,000 |
| National Association of Engine and Boat Manufacturers | 175 |
| New York Electrical Society | 705 |
| Society for Electrical Development | 1,128 |
| Society of Naval Architects and Marine Engineers | 900 |
| Society of Automobile Engineers | 1,975 |
| U. S. Naval Consulting Board | 24 |
| Total | 52,677 |

It will be seen that no societies of chemical engineers or chemists are as yet numbered in this list, nor are any of the societies of railway engineers and superintendents represented.

Ten years ago we advocated the closer affiliation of engineering societies of all kinds, and we were particularly urgent in advising the American Society of Civil Engineers to take the step that it has just taken. Is not the present time propitious for organized effort to bring all the national engineering high standing societies together under one roof? The consolidated technical library would alone justify such a step, but even more important would be the impression produced on the general public as a result of housing in one building technical societies having a total membership of approximately 100,000 men. Inclusive of chemical engineers, chemists, architects, etc., such a total will soon be reached by the combined national engineering societies of America, exclusive of the society that will ultimately outstrip all others in membership—the American Society of Agricultural Engineers.

## "THE AFFILIATED TECHNICAL SOCIETIES OF ATLANTA" AND WHAT THEIR EXAMPLE TEACHES.

At the recent convention of the American Institute of Electrical Engineers, Mr. A. M. Schoen, chairman of the executive committee of the Affiliated Technical Societies of Atlanta, indicated what has been done to bring engineers of all classes together and make their influence felt in civic life.

The association, now three years old, consists of the local sections of all the national engineering and architectural societies and the Engineering Association of the South. The members of the executive committee elects its own chairman. Meetings are held quarterly. Business men address the meetings and the topics of discussion are such as to arouse public interest in engineering matters.

Four city officials of Atlanta occupy positions requiring technical knowledge, yet they are elected by popular vote. The Affiliated Societies have taken steps to have these four offices filled by civil service examinations, the positions being those of city engineer, superintendent of water works, building inspector and electrician.

The Governor of Georgia has been asked to appoint an engineer as member of the Sanitary Board of the state, and has replied that, although he had never before thought about the fitness of such an appointment, he would gladly consider it. Positions on two city boards have been secured for two engineers.

Mr. W. A. Del Mar of New York proposes a national federation of engineers to be called the American Institute of Engineers, the main function of which would be to secure united engineering action in public affairs.

We may add that an equally important function would be giving publicty to the achievements of engineers and the teaching of the fact that modern engineering involves the management as well as the design of engineering apparatus and plants.

If there were such an organization as an American Institute of Engineers, its local branches would correspond to the Affiliated Technical Societies of Atlanta. The idea of Mr. Del Mar is well worth pondering.

## HOW BURNING POWDERED COAL MAY DISPEL THE CITY SMOKE NUISANCE.

In spite of ordinances designed to reduce the great tonnage of soot that descends annually upon our cities, few manufacturing municipalities can yet claim to have secured marked relief from the "smoke nuisance." But relief is apparently in sight, and from a totally unexpected source. We refer to the successful development of the process of burning powdered coal for generating steam in locomotive and other boilers.

Pulverized till 85 per cent of it passes a screen having 200 meshes to the inch, "soft coal" gives an almost smokeless flame when blown into a fire box with air. The quantity of air is automatically regulated by the quantity of powdered coal, so that careless firing, such as is now inevitable with hand stoking, can not occur.

Between Chicago and Milwaukee, the Chicago & North Western placed in service, a year ago, a passenger locomotive equipped for burning pulverized coal. It has been thoroughly tested in active service, and has demonstrated a marked saving in fuel. According to tests published in the Railway Age Gazette, this locomotive evaporated 13 per cent more water per pound of coal and consumed 18 per cent less coal on the runs between Chicago and Milwaukee than was required with a similar locomotive fired with lump coal in the ordinary manner. Moreover, a much cheaper grade of coal was used on the locomotive burning pulverized coal.

In firing up the cold locomotive, only 750 lb. of powdered coal were required as against 1,700 lb. of lump coal. But an even greater point in favor of powdered coal is the ability to shut off the fire entirely while standing still. Thus the fire can be entirely shut off for about half an hour, yet in 5 min. after it is started again the boiler is up to full pressure. This saving in fuel while standing idle makes powdered coal particularly desirable for switching locomotives.

The switching engines in the freight yards of cities and the engines that are getting up steam or standing with banked fires, cause a very large part of the "smoke nuisance" that has been so greatly deplored in all large cities. It would seem now that, as far as locomotives are concerned, this nuisance need no longer be tolerated. We go farther, and predict that all large steam power plants in cities will eventually use powdered coal, not only because it will prove to be more economic, but because a smokeless city can be secured in this way.

## EDITORIAL COMMENT.

Another structural engineer has been given an executive position of great importance. Mr. George H. Blakeley, M. Am. Soc. C. E., has been made president of the Bethlehem Steel Bridge Co., a newly organized company that is to handle the structural work of the Bethlehem Steel Co.

A society of structural engineers is needed not so much to secure adequate discussion of the technicalities of designs as to educate the public. This education should begin by teaching the incontestible fact that nine-tenths of the design of fireproof buildings is pure engineering, the other tenth being architectural art. In short, it should be shown to the prospective employers of designers of fireproof buildings—to the building owners—that commissions for designs should be placed in the hands of structural or architectural engineers.

Many an architect of the old type has evolved into a structural engineer, and as such should not hesitate to declare himself. It seems to us, however, that such declarations will not come until structural engineers shall, by organized publicity, make it universally recognized that to be an engineer—an economist—is more important than to be an architect—an artist.

One of the oldest iron bridges in America has just been removed to make way for a steel bridge. We refer to the Keokuk (Ia.) and Hamilton bridge, consisting of 11 Whipple truss spans placed in service in 1871. The bridge carried highway and rail traffic and was operated as a toll bridge. The old masonry piers were in such good condition the new steel spans were placed upon them, only slight changes being made.

The average railway employe of British railways received $364 a year in 1913, or about 44 per cent as much as the average railway employe in America. British locomotive crews averaged $412 per year per man, or about 30 per cent as much as the American average. The highest class enginemen in America average more than $2,000 a year, and the highest class conductors average nearly $1,800 a year. Well may American trainmen be called the "aristocrats of labor."

Building permits for the first seven months of 1916 totaled nearly $610,000,000, which is an increase of 29.4 per cent over the corresponding period of 1915. If this rate is kept up during the rest of 1916 more than a billion dollars worth of building permits will have been issued during 1916 by the cities of America. General prosperity is indicated by this enormous total of building construction.

Why do not more architects and engineers form partnerships? Perhaps the answer is partly to be found in state laws that prevent engineers from being "registered architects." Structural engineers in particular should organize to effect changes in such laws.

## COMMENT ON A SOCIETY OF STRUCTURAL ENGINEERS.

To the Editors: We are very much interested in your article in the July 26 issue of Engineering and Contracting. We certainly believe that the need for such an organization exists, and we will be more than glad to give the movement every support within our power.

Very truly,
The General Fireproofing Co.,
W. B. Turney, Advertising Manager.

Youngstown, O., July 29, 1916.

To the Editors: I note your article on The Possibilities of a New Society of Structural Engineers, and will say that I am very much interested in this and will be glad to hear further concerning it.

Yours very truly,
Des Moines Bridge & Iron Works,
By F. H. Marsh, C. E.,
Sales Manager Structural Department.
Des Moines Bridge & Iron Works.

Des Moines, Ia., July 27, 1916.

To the Editors: I have read with a great deal of interest editorial which deals with the suggestion of a proposed American Society of Structural Engineers. The reasons outlined in the editorial referred to for the existence of a society of structural engineers cannot be denied, nor can they be criticised from any point of view.

This is very distinctly an age of specializing, and this applies to the professions as well as to other natures of business. The modern and adequate building of today is an engineering problem, its success or failure depending almost entirely upon the excellency of the engineer's judgment in the mechanical equipment of the structure, as well as the general layout of structural members in order to provide the best possible conditions for the purposes to which the building is to be put.

The foundation of a society of structural engineers is a step in the right direction, and will be conducive to exchange of thought and ideas among engineers who specialize upon structural propositions, all of which will result in a wider knowledge of the many vital principles which enter into the structural design of the present modern building.

Yours very truly,
Virgil G. Marani,
Consulting Engineer,
Am. Soc. C. E.

Chicago, Ill., Aug. 3, 1916.

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To the Editors: After reading the proposed editorial which is to appear in the Building and Structural issue of your magazine, the writer being a bridge and building erector of 25 years' experience in the construction of some of the largest bridges and buildings in the country, has the following to say:

Having come in contact with prominent architects in different parts of the country while erecting large structures and buildings, both manufacturing and office buildings, the writer has found that architects absolutely depend, as a rule, on the skill of their structural engineers in relation to the stability and utility of the building; that when it came to the changes of any kind from the original drawings it is usually the question of the architect waiting to consult the designing engineer before giving his decision.

The writer is somewhat surprised that there has not been, long ago, a society or an organization of some kind of structural engineers, and believes that if such an organization existed the designing and erecting engineer would get the credit which belongs to him.

The writer notes the statement in your article that there are states that have laws which prevent any one save a licensed architect from having charge of the designing of a large building, and believes that that is radically wrong and that the engineer's ability and training so far exceed the architects that there is no comparison. It is absolutely true, as you state in your article, that it is necessary for the structural engineer to educate the general public, as the general public, in regard to a structure of any kind depends entirely upon and thinks entirely of the architect. As a rule it does not even know that there is a designing engineer behind the architect who figures the tensile strains, the compression strains, the wind and vibration strains of the structure the architect has in charge, as well as the load per square foot the structure has to carry, and the writer absolutely believes that the engineer should be the man in charge of the structure, and the architect a secondary consideration.

While the writer does not know whether it was an architect or a civil engineer who designed the Pennsylvania Railroad Station and the New York Central Station in the city of New York, he has been in both of these stations, and, taking them as a comparison, it looks as if the New York Central Station job was done by a civil engineer who had in view both utility and revenue. While the Pennsylvania Railroad Station is a fine piece of massive architecture, the writer believes that there are a few million dollars wasted in the construction of such a massive structure owing to the fact that the job in itself looks like an architect's proposition. If it had been an engineer, he probably would have designed it so that there would not be such a massive amount of material in its construction without some kind of revenue coming in on such a valuable piece of property as the Pennsylvania Railroad Station is located upon.

The writer may be radically wrong in the above stated ideas, but it is the viewpoint of an erecting contractor who is speaking from experience.

Very truly yours,
M. H. McKenna.

Cleveland, O., July 20, 1916.

## BOOKS FOR THE STRUCTURAL ENGINEER.

**Live Load Stresses in Railway Bridges.**—By George E. Beggs. John Wiley & Sons, Inc., New York. Cloth, 6x9 in.; 123 pp.; illustrated. $2.00

Stresses in railway bridges caused by moving concentrated loads are treated in this work by the combined use of influence lines and algebraic methods. The text is largely a development and application of two equations for solving the maximum live load stresses in any structure whose influence lines can be drawn. The general equations are also transformed and simplified to meet the solution of stresses in the simple structures commonly met in practice. The work of solving stresses is expedited by the inclusion of tabular data. The application of the formulas is made clear by means of a number of examples fully worked out. The book will be found of interest and value to students in structural engineering and to practicing engineers engaged in bridge work.

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**Concrete Silos.**—By E. S. Hanson. The Cement Era Publishing Co., Chicago. Cloth, 5x7½ in.; 171 pp.; illustrated. $1.50.

The book treats of the advantages of concrete silos, and of the design and construction of the different types. It is largely a compilation of what the author considers best in the scattered literature relating to concrete silos. The design and construction of the silos are rather fully covered by descriptive matter, drawings and construction views.

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**Bridge Foundations.**—By Wm. Burnside. D. Van Nostrand Co., New York. Cloth, 4½x7 in.; 136 pp.; illustrated. $1.50.

This is an English book and is intended only as an introduction to the subject of bridge foundations. The book is not as comprehensive as are American books on foundations. The subjects treated are: The foundation bed, abutment and pier foundations, pile foundations, dams, screw piles, well foundations, stranded caissons, open and pneumatic caissons, and the effect of compressed air. Tabular data relating to bridge foundations are also included in the text.

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**Structural Timber Hand Book on Pacific Coast Woods.**—By O. P. M. Goss and Carl Heinmiller. Pacific Coast Lumbermen's Association, Seattle, Wash. Leather; 5x8 in.; pp. 289; illustrated. $1.

This volume will be found particularly useful by engineers and contractors because of the extensive tabulations of safe total loads and other properties of beams. These tabulations occupy about 175 pages or about three-fifths of the book. Tables show the safe total loads and corresponding deflections for rectangular beams of various sizes. The number of pounds per board foot of lumber, supported by beams, is also shown, which will assist in effecting economical designs. Tables have been computed which show the safe loads on beams limited by the horizontal shearing stress. Other tables show safe total loads on columns of various sizes and still other tables give the maximum spans for mill and laminated floors, board measure for various dimensions and lengths, and board measure and weight for unit lengths of Douglas fir dimension timber.

Data and figures are given on timber frame-brick mill buildings, showing costs, insurance rates, and details of construction. Standard formulas for computing stresses covering the usual practical conditions are given. A grading rule for securing structural timbers of high strength is also included.

Considerable data are presented on the creosoting of Douglas fir lumber in various forms, such as bridge stringers, mine timbers, piling, ties, bridge caps, paving blocks, silo staves, and other forms. Space is devoted to wooden silos and red cedar shingles. Kiln drying lumber is briefly discussed as well as other subjects of interest to the consumer of wood.

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**The Elasticity and Resistance of the Materials of Engineering.**—By Wm. H. Burr. John Wiley & Sons, Inc., New York. Cloth, 6x9 in.; 919 pp.; illustrated. $5.50.

In this, the seventh edition of this well known work the text has been thoroughly revised, the new material constituting about three-fourths of the volume. Results of the most recent experimental investigations have been used for the requisite empirical data to make the book a real work on the elasticity and resistance of materials of engineering rather than a mere matter of applied mechanics. The treatment of reinforced concrete in this edition has been extended to cover substantially all the principal features of that special field.

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**Simplified Reinforced Concrete Mathematics.**—By Melvin D. Casler. D. Van Nostrand Co., New York. Cloth, 5x7½ in.; 66 pp.; illustrated. $1.

The stated purpose of this booklet is to provide practical working formulas for the design and investigation of reinforced concrete members and means for applying the formulas with a minimum of computations. There are also given some labor-saving devices for use in proportioning members. By means of problems the application of the formulas and devices are clearly shown.

**Surveying Manual.**—By William D. Pence and Milo S. Ketchum. McGraw-Hill Book Co., New York. Leather; 4¼x7 in.; 384 pp.; illustrated; $2.

This is the fourth edition of this well known surveying manual. In this edition the text has been enlarged, nearly all of the cuts have been redrawn, natural, logarithmic and trigonometric tables have been added, and the entire book has been reset and recast. The execution of the sample problems is excellent, and the revision has greatly increased the usefulness of the book.

**The Stability of Masonry.**—By Ernest H. Sprague. Scott, Greenwood & Son, London; D. Van Nostrand Co., New York, Distributors; Cloth; 4½x7 in.; 163 pp.; illustrated; $1.50.

This is an English work treating of earth and water pressures on walls and other structures and of the stability of such structures. A very full treatment of the subject is given, in which graphical methods predominate.

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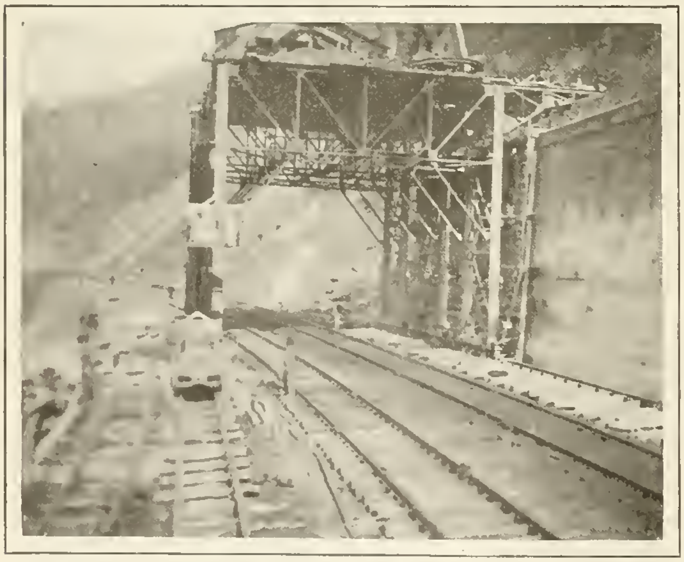
## STEEL TRAVELER AND FORMS FOR RETAINING WALL CONSTRUCTION.

A retaining wall approximately 28 ft. high carries, along a side hill near Paw Paw, W. Va., the tracks of the new Magnolia cutoff of the Baltimore & Ohio R. R., close to the main line tracks. To construct this wall and not interfere with traffic on the main line a traveler and steel form were used, as illustrated. The difference in level of the two lines is 28 ft., so that this is the neat height of the wall, but at places the wall footing extended 11 ft. below the neat line level. The wall is of concrete of gravity section and the traveler handled all concrete and all excavation from the footing trench and also carried the wall forms.



Traveler and Forms for Concrete Retaining Wall Construction.

The illustration shows the general construction of the traveler. It was 50 ft. long and 35 ft. high, and as it straddled the main tracks it was 34 ft. wide. On one side a cantilever extended the traveler platform over the wall. An 80-lb. rail on each side of the main tracks formed a traveler track. Three trucks of four tandem wheels each on each side of the traveler rode on the traveler track, the traveler being moved ahead by lines fastened ahead to deadman. On the traveler were mounted two stiff-leg derricks separately engined. These derricks handled the excavation and the concrete. Concrete mixed at a central plant about one-half mile away was brought on a service railway in buckets on cars; the buckets were handled by derrick and emptied through holes in the cantilever platform. This platform also carried by suspension the steel forms. They were 50 ft. long and 30½ ft. high and were equipped with turnbuckles and jackscrews for adjustment.

In construction the wall forms were generally allowed to stand two days or longer for the concrete to harden, but a form could be and was at times, filled and removed in 15 hours. The contractors were the Smith-McCormick Co., Euston, Pa., for whom the forms were built by the Blaw Steel Construction Co., Pittsburgh, Pa.

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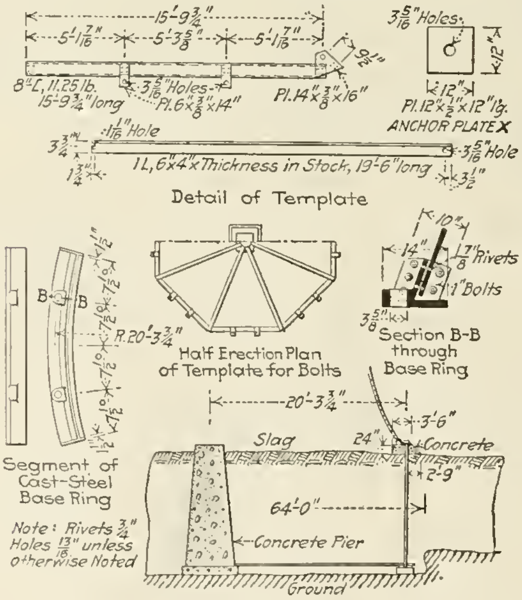
## CONSTRUCTING A STEEL CHIMNEY FOUNDATION OF MOLTEN SLAG.

Molding a block of molten slag for a steel stack foundation is described by A. G. McGregor in the August Transactions of the American Institute of Mining Engineers. The description follows: The drawings show the details of the foundation for a steel chimney at the smelting plant of the Calumet & Arizona Mining Co. at Douglas. The chimney is 305 ft. high from the top of the foundation and is 25 ft. 9½ in. in diameter, inside of the steel shell. It has a hollow-tile lining 4 in. thick throughout its height. The feature of the chimney is in the construction of its foundation.

The foundation was cast from molten slag hauled to the site for the chimney in the usual slag pots, instead of concrete or masonry as is usual for chimneys of this type. A template for holding the anchor bolts was made of structural angles and channels supported on a central concrete pier and held from turning or moving by a second concrete pier at the outer circumference. The foundation bolts were supported at their lower ends on small crete piers and they in turn supported the template at other points of its outer circumference not supported by the concrete pier, each bolt having at the top a nut on the under side and one on upper side of the template, forming a secure support. Large washers were provided for the bottom ends of the anchor bolts over which were laid old steel rails. Blast-furnace slag was then poured over the foundation and adjacent ground, forming the foundation for the chimney. A concrete capping was laid on top of the slag for the cast-steel base-ring of the chimney proper.



Details of Slag Foundation for a Steel Stack.

# METHODS AND COST OF CONSTRUCTING A REINFORCED CONCRETE STOREHOUSE.*

The structure as shown by Fig. 1 consists of a six-story main building 100x250 ft. and of a one-story crane runway annex 50x250 ft. The construction is reinforced concrete except the exterior brick curtain walls of the main building and the roof of the annex which is steel frame with ferroinclave roofing. The description following relates in the main to the reinforced concrete work alone.

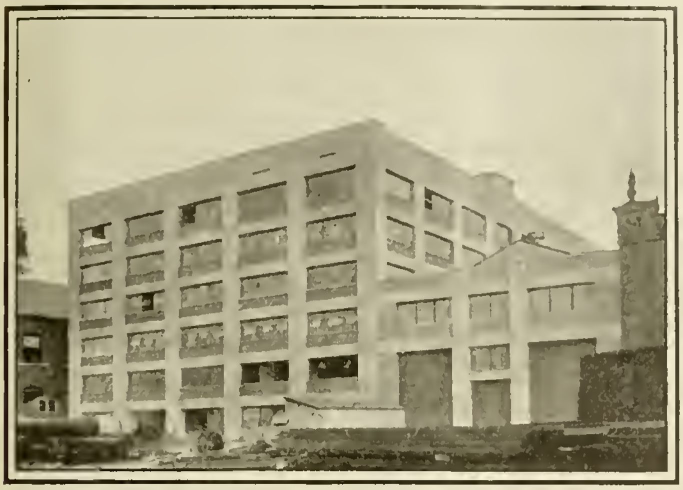


Fig. 1—Reinforced Concrete Storehouse.

## Structural Features.

**Foundations.**—The building has pile foundations designed for a loading of 20 tons per pile, penetrating through partly consolidated filling and alluvial deposits to a fairly flat layer of gravel and sand at a depth of about 43 ft. below cut-off. The piles were driven by drop hammers weighing 2,500 lb. and the slow rate of progress, averaging only 11.4 piles per driver per day, gave a striking illustration of the inefficiency of this antiquated method of driving.

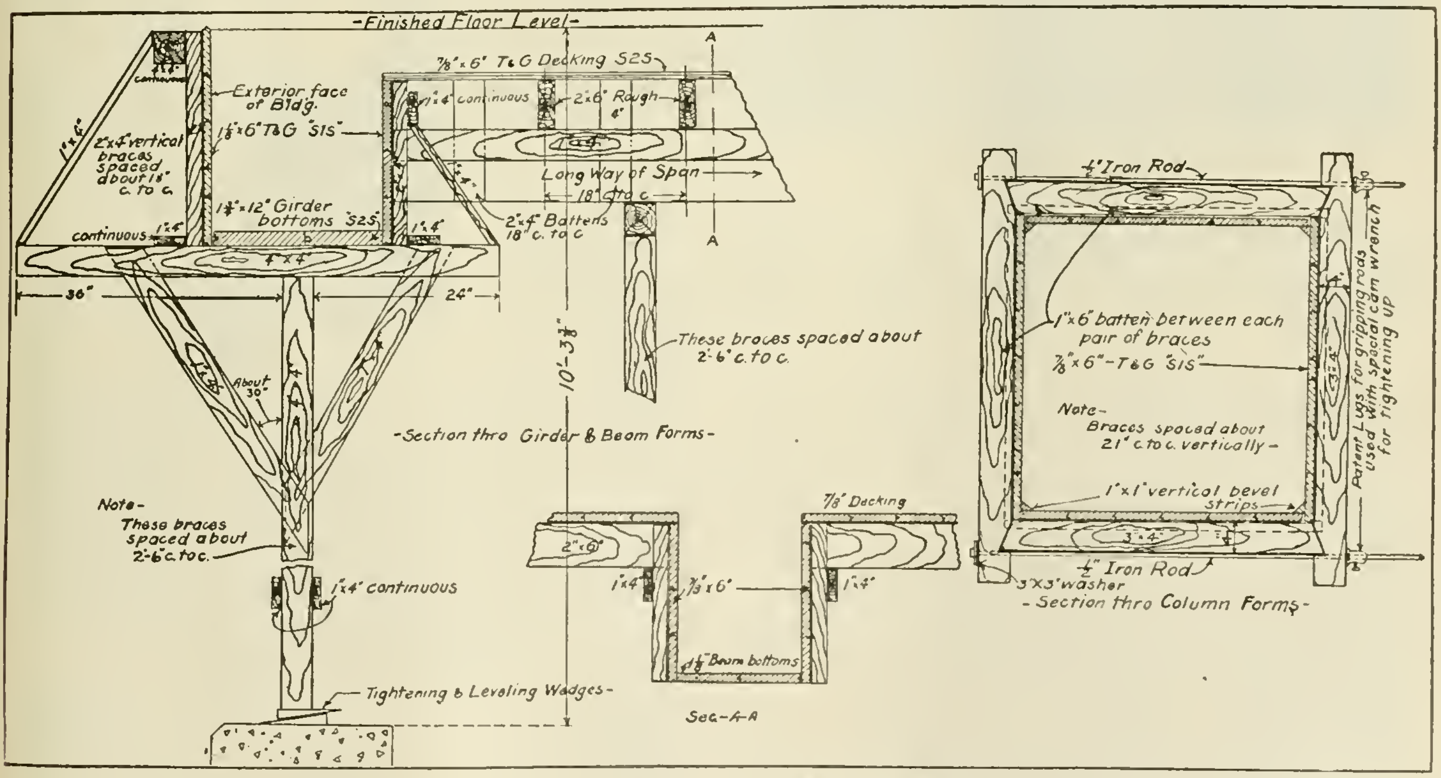

-Finished Floor Level-
7/8"x6" T&G Decking S2S
Exterior face of Bldg.
1⅛"x6" T&G "S1S"
2"x4" vertical braces spaced about 18" c. to c.
1"x6"
continuous
1"x4"
1¾"x12" Girder bottoms "S2S"
1"x4"
4"x4"
1"x4" continuous
2"x6" Rough
4"
Long Way of Span
18" c. to c.
2"x4" Battens 18" c. to c.
A
A
36"
24"
About 30"
10'-3⅜"
These braces spaced about 2'-6" c. to c.
-Section thro Girder & Beam Forms-
Note-
These braces spaced about 2'-6" c. to c.
1"x4" continuous
Tightening & Leveling Wedges-
2"x6"
1"x4"
7/8"x6"
1"x4"
7/8" Decking
1½" Beam bottoms
Sec.-A-A
½" Iron Rod
1"x6" batten between each pair of braces
7/8"x6"-T&G "S1S"
Note-
Braces spaced about 21" c. to c. vertically-
1"x1" vertical bevel strips
3"x4"
3"x4"
½" Iron Rod
3"x3" washer
Patent Lugs for gripping rods used with special cam wrench for tightening up
- Section thro Column Forms-

Fig. 2—Form Details for Concrete Storehouse.

The concrete piers were 1:3:6 gravel concrete, chuted into place, the pile heads being embedded 6 in. in the concrete. Reinforcing bars were provided in each pier just above the pile heads, apparently to tie the pier together; these were unnecessary.

**Columns.**—The columns were designed for the total dead load plus 75 per cent of the live load. The columns are square, 3x3 ft. with eight $1\frac{5}{8}$-in. diameter round rods in the first story, diminishing uniformly at each story to 12x12 in. with four $\frac{3}{4}$-in. diameter round rods in the sixth story. At the first story the longitudinal reinforcement is 1.5 per cent of the effective area, and at the sixth story 2.2 per cent. One-fourth inch diameter round hoops were used spaced 12 in. apart; the percentage of hooping is as a result very small, and the columns were therefore designed as with longitudinal reinforcement only, the compression being limited to 450 lb. per square inch (being $22\frac{1}{2}$ per cent of 2,000 lb.). Considering the first-story columns, which are square, as having a diameter of 36 in., a spiral hooped column of octagonal or circular section with a diameter of 29 in. would have given equal strength. The equivalent steel column of 14-in. H section fireproofed would be approximately 19 in. square.

**Floor Systems.**—The first floor rests directly upon the ground; the upper floors and roof were designed for the following live loads: Second floor, 400 lb. per square foot; third, fourth, and fifth floors, 250 lb.; sixth floor, 150 lb.; and roof, 40 lb. The computations for strength did not include the $\frac{3}{4}$-in. thickness of cement finish, as a part of the load carrying capacity of the structure. The finish was in every case placed on the same day as the concrete, and a large element of strength was thereby added. Master builders' hardener was used in the finish, with excellent results, as the floors are dustless and show no tendency whatever to wear under the iron wheels of hand trucks which would otherwise by now have caused considerable wear. With the high-grade cement and mortar used in present day practice, it would unquestionably be justifiable to measure the thickness of a slab as including the finish, especially where the use of a hardener and of other protective measures will prevent any considerable wear.

The design of the floor systems is otherwise extremely liberal. For the second floor, where the design provides a total slab thickness of $5\frac{3}{4}$ in., a strict application of the recommendations contained in the 1913 Report of the Committee on Concrete and Reinforced Concrete appointed by the American Society of Civil Engineers would permit theoretically a slab $4\frac{1}{2}$ in. thick; the center-to-center span is 6 ft. 4 in., the clear span 5 ft., and the slab could accordingly be figured on a span length of 5 ft. 4½ in.

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*Condensed from an article by Civil Engineer E. R. Gayles, U. S. N., in Public Works of the Navy for June, 1916.

The 1:2 cement finish used on this work has an ultimate compressive strength of more than 3,600 lb. per square inch, which would justify a working stress, in compression, of 1,000 lb. per square inch, in accordance with the committee's recommendation. There is no reason why use should not be made of this element of strength in the computations of T beams.

In the slabs alternate reinforcing rods were carried through straight past supports, and alternate rods were trussed over supports. Short rods were put in for tension rods over supports between the trussed rods.

Following the committee's recommendations, which limit the compressive stress in concrete at supports to 32.5 per cent of the compressive strength of the concrete, increased by 15 per cent, or in this case to 750 lb. per square inch, the design of the beams and girders was determined as much by compressive stress due to reverse moments at supports as by bending moments at the middle of the spans or shears. These compressive stresses are carried by the bottom reinforcing rods, a part of which are carried through straight; in this building the bars were cut to the exact length of center spacing of columns and were butted together to transmit the compression. This arrangement is simple and practicable and is preferable to hooking the ends of the bars.

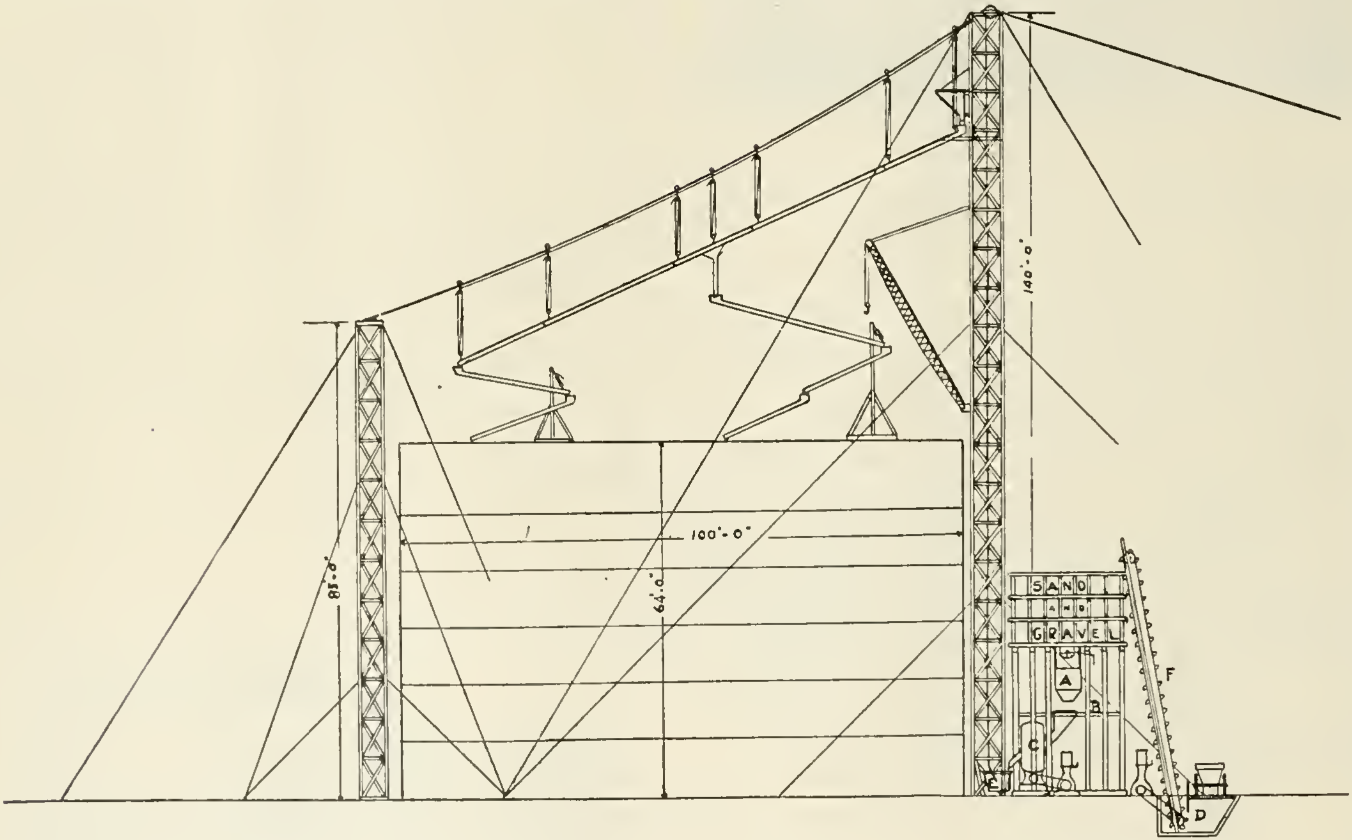


Fig 3—Concreting Plant for Concrete Storehouse.

It is still more preferred, however, in order to insure against vertical cracks in the lower portion of beams and girders adjoining supports, to carry the bottom reinforcing rods through past the center of the supports a sufficient distance to transmit the stress in the bars into the next beam or girder, the exact distance to be determined by bond resistance.

The first floor is of creosoted pine blocks laid on a 6-in. concrete base, with a sand cushion ¾ in. thick between and with sand-filled joints. Under the heavy wheel loads of motor trucks the blocks work loose and break. This condition is being remedied by pouring the joints with roofing tar.

**Forms.**—The forms were made of tongued-and-grooved pine; new lumber was provided for forms for three stories, and the same forms were altered and repaired for the upper two stories and roof. Figure 2 shows typical form construction, which is simple and strong.

**Handling Concrete.**—The concrete was hoisted by tower and chuted into place. Figure 3 shows the arrangement of tower and chutes. The low cost of mixing and handling speaks for itself. The consistency was such that no spading next to forms was required; in fact, none was possible on account of the presence of reinforcing metal. The requirement for spading against forms should be eliminated from modern specifications for reinforced concrete, as it is impracticable and is also unnecessary because with the proper consistency, smooth surfaces can be obtained by agitating the wet concrete and by occasionally rapping the forms to release air bubbles.

**External Finish.**—A handsome external finish was obtained by applying a 1:2 grout with brushes, and rubbing it on with cork floats. In this connection, it may be remarked that an exceptionally fine finish has been given the concrete work of the power plant at Indianhead by rubbing the surfaces with carborundum bricks and then brushing on grout. This finish would be suitable for large surfaces of concrete walls and entirely avoids the uneven splotched appearance of ordinary concrete work, and costs less than ½ ct. per square foot.

**Joints.**—There were no expansion joints provided in the building. No serious cracks have developed thus far; in fact, there is very little cracking of any kind. Day's work joints were made at right angles to the axis of the building, and one joint in each floor at about the middle of the building has opened up slightly, due to shrinkage.

In a building of this length it would be desirable to put in an expansion joint near the middle of the building.

### Construction Costs and Methods.

The wages paid labor was as follows:

| | Per hour. |
|---|---|
| Bricklayers | $0.67 |
| Carpenters | .55 |
| Steel erectors | .62 |
| Cement finishers | .50 |
| Plasterers | .62 |
| Common laborers | .20 |

**Concrete.**—The total cost of the reinforced concrete, not including finish, was as follows:

| | |
|---|---|
| Labor | $0.76 |
| Materials | 3.08 |
| Reinforcement | 3.89 |
| Forms | 3.07 |
| Plant | .43 |
| Total | $11.23 |

The cost of 1:3:6 foundation concrete was as follows:

| | |
|---|---|
| Labor | $0.78 |
| Materials | 2.65 |
| Reinforcement | .60 |
| Forms | .20 |
| Plant | .43 |
| Total | $4.66 |

Materials were received in bottom dump wagons. Labor cost includes dumping materials into receiving hopper, handling by bucket conveyor to bins, mixing, hoisting into tower, chuting, distributing and working into place, setting anchor bolts and column dowels.

The concrete of the first floor was handled by industrial track and tip cars; including placing track, etc., 2,670 sq. yd. cost $0.81 per square yard for labor and material for 6-in. floor without cement finish.

Reinforcing steel for 5,264 cu. yd. reinforced concrete weighed 1,170,000 lb., corresponding to an average throughout the building of 8.2 lb. reinforcement per cubic foot of concrete, or 1.7 per cent, and cost $3.89 per cubic yard of concrete, at the rate of $0.0175 per pound in place.

Forms were generally used twice. Forms for 5,264 cu. yd. reinforced concrete cost $17,200, or $3.07 per cu. yd. There were 247,500 sq. ft. of forms used in the entire building, costing $0.024 per square foot for labor and $0.045 per square foot for materials, total $0.069 per square foot of forms in contact with concrete. Cement cost $1.10 per barrel net; sand $0.98, and gravel $1.20, per cubic yard.

**Concrete Plant.**—This plant placed 7,184 cu. yd. concrete, and cost $8,061.92; its estimated salvage value is $5,000, making the net cost for plant $3,061.92 or $0.43 per cubic yard. If the entire cost of the plant is charged into the concrete the cost is $1.13 per cubic yard.

**Slab Roof.**—The concrete roof of the main building cost, per square foot:

| | |
|---|---|
| Concrete 4 inches thick | $0.047 |
| Steel reinforcement | .026 |
| Forms | .069 |
| Slag roofing | .053 |
| Total | $0.195 |

**First Floor.**—Total cost of first floor, per square yard:

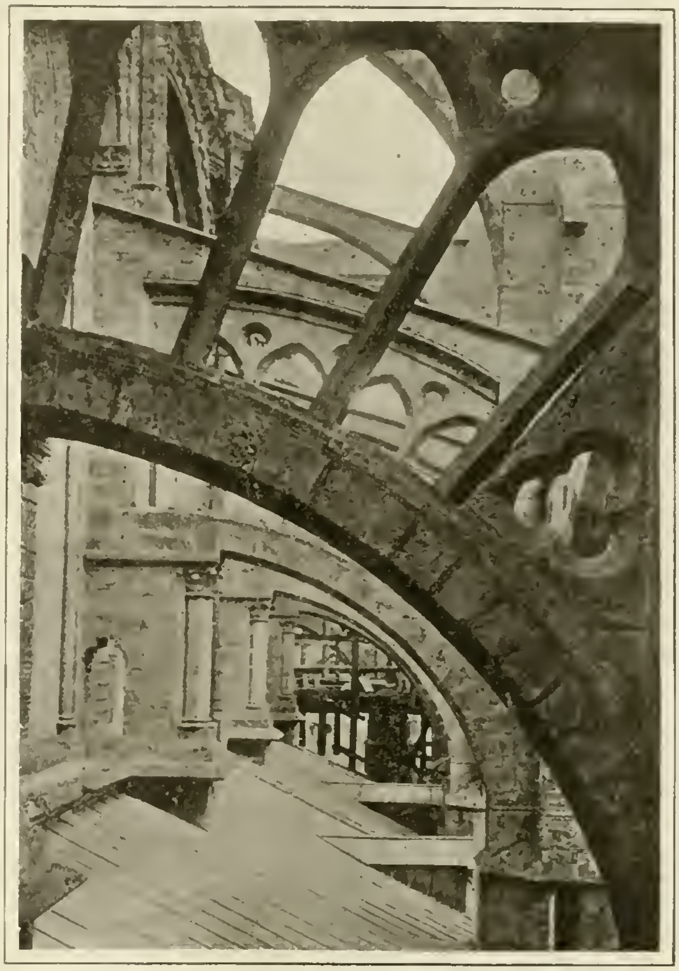
| | |
|---|---|
| Concrete base, 6 inches thick | $0.81 |
| Wood blocks | 1.17 |
| Pitch and sand | .07 |
| Total | $2.05 |

The contractors for the building were the George E. Wyne Co., Munsey Building, Washington, D. C., Mr. Elmon A. Miller, general manager.

## EMPIRICAL ARCH DESIGNING OF THE GOTHIC BUILDER.

One of the structural features of the Gothic church buildings of Europe which most invariably excites the interest of the structural engineer is the seemingly illogical complexity of flying arches. An excellent example of this complication of arch numbers is shown by the accompanying part view of Chartres Cathedral reproduced from the "Architectural Record." Why was this complexity of difficult arch construction? In a paper on the Logic of Gothic Architecture, Mr. A. D. F. Hamlin answers the question as follows:

The so-called flying-buttress is now perfectly well understood as the one essential feature without which the French Gothic development of loftiness and of suppression of walls—the Gothic system of the framed skeleton of stone—could never have been realized. By its means alone was it possible to reduce the mass and area of all the supports, increase all the heights, and enlarge the clearstory windows to splendid dimensions. By its means the weights were distinguished from the thrusts. These last were concentrated by the ribs of the groined vaulting into strains exerted at particular points, namely somewhere in the clearstory above each pier. The "flying" or half-arches abutting against the clearstory between each pair of windows receive these thrusts and transmit them across and above the side-aisle roofs to the buttresses proper. These last are masses of masonry, very deep in the direction of the thrust, i. e., transversely to the length of the church. The fundamnetal logic of the flying-buttress consists, first, in applying localized resistances to the localized thrusts; and, secondly, in applying this resistance by means of the half-arch as nearly as possible at the central or critical point of outward pressure of the vault. But since the engineering science of the French Gothic builders was empirical, not mathematical, they had to guess at the point where the thrust would emerge (i. e., most forcibly press outward), and they made many mistakes in their guesses.



Flying Arches of Chartres Cathedral.

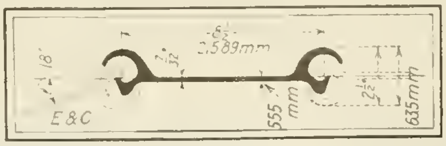
Some of the early half-arches are very high, some low; some very thin and light, some very deep. As the style advanced, the arches were made lighter and were doubled, one above the other, thus making sure of catching the thrust between them.

## A NEW SECTION OF LACKAWANNA STRAIGHT WEB STEEL SHEET PILING.

The $8\frac{1}{2}$-in. section steel sheet pile was designed for use where a comparatively light section is required with high transverse strength and minimum weight, in medium trench and cofferdam work.

The interlocked joint formed between adjacent piles is flexible through an arc of 18° on each side of the center plane of the piling section. The hooks of adjacent sections engage to offer the greatest resistance to longitudinal displacement while the guards overlap and engage the outer surface of the hooks on the adjacent sections, thus preventing lateral displacement and co-operating to prevent longitudinal displacement. The joint can be disengaged only by withdrawing one pile. There are three lines of contact between the interlocked members of each joint, so that there is a positive, double, firm and close interlock, yet a minimum of friction in driving or withdrawing and ample opportunity for displaced material to work into the joint and assist in rendering it watertight, while at the same time the interlock holds the piling in proper alignment to form the wall.

In the development of this new section, special attention was given to secure for this joint high tensional and transverse strength, and at the same time to produce a pile which would have comparatively low weight per square foot, be simple, interlock perfectly, and have the material so distributed as to give a high section modulus per lineal unit of wall. Lackawanna Steel Sheet Piling is made by the Lackawanna Steel Co., Lackawanna, N. Y.



Lackawanna Sheet Pile.

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## AUTOMATIC SAFETY BRAKE FOR HOISTS USED IN CHICAGO FOUNDATION SHAFT SINKING.

A standard method of foundation construction for tall buildings in Chicago is to sink circular shafts through the overlying clay blanket 50 to 100 ft. thick to ledge rock or hardpan and fill these shafts with concrete. Generally there is a shaft for each foundation column so that for a large building many shafts are required and the task of excavation becomes one of importance in the mere matter alone of handling the spoil out of shaft. The usual hoisting outfit is of the type shown by Fig. 1; several of these hoists in a row are commonly driven by an endless steel cable operating over the driving sheaves. It is obvious from inspection that, should driving cable slip off a sheave while the bucket is being hoisted, the pull would reverse the rotation of the sheave and the bucket descending the shaft would fall on the workmen at the shaft bottom. To safeguard against this mishap the safety brake shown by Fig. 2 has been devised and put on the market by French & Allen, manufacturers of contractors' equipments, 508 S. Canal St., Chicago, Ill.

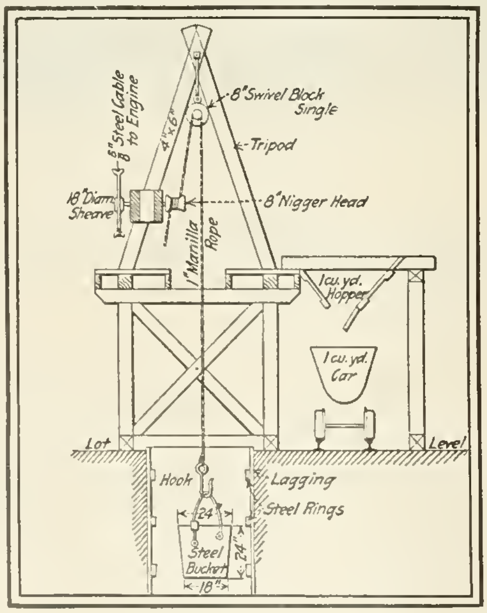

Fig. 1—Head Frame Hoist.

Between the timbers which carry the sheave and within head shaft is bolted a casting A within which runs a brake wheel B keyed to the shaft. The two slots, C, $C_1$, in the casting are eccentric with respect to the brake wheel; they provide for the brake shoe D as indicated. Referring to the drawing, the shaft usually revolves in the direction shown by the arrow, and so revolving the brake shoe rides up on the wheel with very little friction. Reversal of the direction of revolution, as would result from a falling bucket, carries the brake shoe down and the eccentric slot C causes it to wedge and stop the wheel. If the normal operation of the shaft is the reverse of that indicated the brake shoe is shifted to the opposite slot $C_1$. This reversibility of the braking action is a particular feature of the device being described. Another feature emphasized is its quick action.

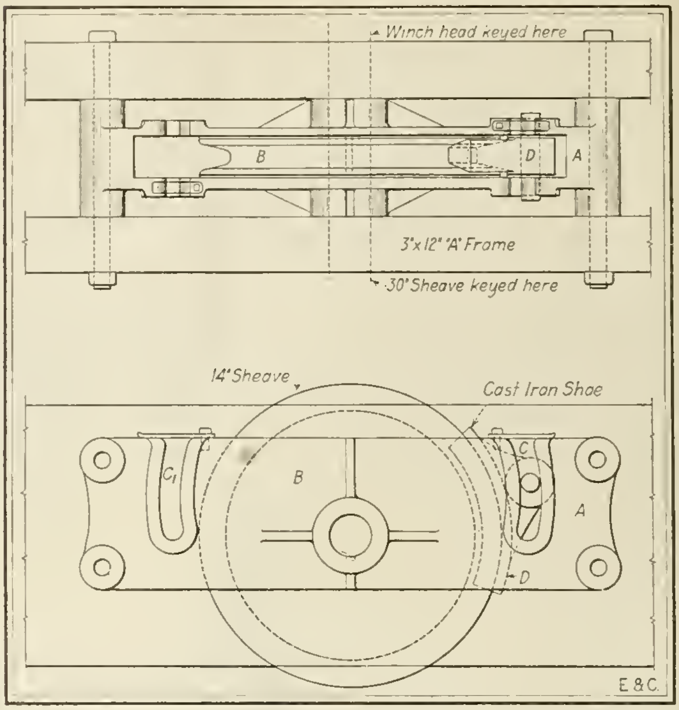

Fig. 2—Safety Clutch for Hoist.

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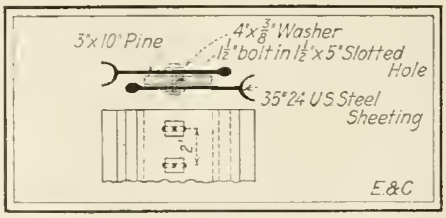
## PRACTICAL CLOSURE SHEET FOR SINGLE WALL STEEL SHEET PILE COFFERDAMS.

Contributed by Carl O. Johnson, Department of Public Works, Bridge Division, Chicago, Ill.

Closing a single wall steel cofferdam is often a troublesome procedure, especially when the work must be done in deep water, or where sheeting comes together ball to ball or socket to socket. Mr. Murphey of the Great Lakes Dredge and Dock Co. devised a scheme which worked very satisfactory in the steel dam for the Belmont Ave. Bridge, Chicago. Here the sheeting came together, ball to ball, in a wedge-shaped opening in about 15 ft. of water. The excavation inside the dam was subsequently made 20 ft. Two 35 lb., 24 ft. U. S. Steel sheets, with 3x10-in. S4S pine filler between, were lightly bolted together with $1\frac{1}{2}$-in. bolts working in $1\frac{1}{2}$x5-in. slotted holes about 2 ft. apart and protected by 4x$\frac{3}{8}$-in. square washers. All parts were well greased, and all nuts placed on inside of dam.


3"x10" Pine
4"x$\frac{3}{8}$" Washer
$1\frac{1}{2}$" bolt in $1\frac{1}{2}$"x5" Slotted Hole
35# 24 U.S. Steel Sheeting
2'
E&C

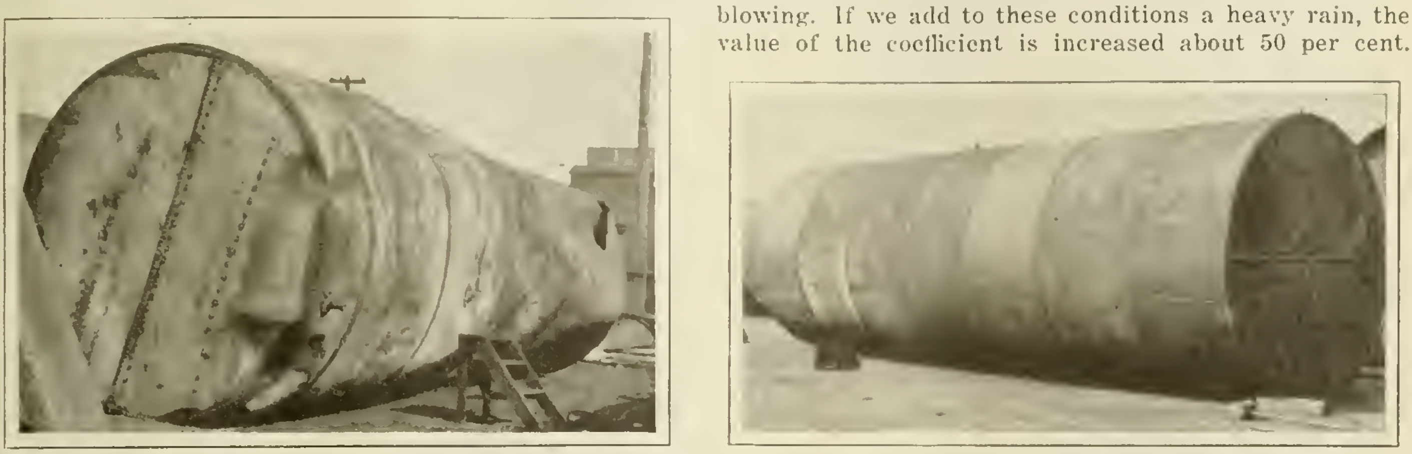
Closure Detail for Sheet Piling.

After sheet was driven, bolts were tightened from inside of dam as pumping and excavation proceeded. Slotted holes were made by first drilling three $1\frac{1}{2}$-in. holes and cutting away material between with cold cutter. The cost was:

2 machinists, total 40 hr., drilling 66 $1\frac{1}{2}$-in. holes.
2 machinists, total 8 hr., cutting 22 $1\frac{1}{2}$x5-in. slots.
1 carpenter, 4 hr., fitting 3x10-in. filler.
Total, 52 hr., @ 65 ct. = $33.80.

## OIL TANKS BEFORE AND AFTER TAKING PNEUMATIC HAMMER TREATMENT.

At the left in the accompanying illustration is shown an oil tank as it came from a fire in a plant of the Texas Oil Co. It is one of twelve tanks, each about as badly banged up and each 10 ft. in diameter and 30 ft. long. At the right in the illustration is shown the battered tank after it had been repaired. The right hand picture is a testimonial of the efficacy of pneumatic tools. To restore the tank the contractors, the Johnson & Barry Steel Co., Birmingham, Ala., used pneumatic hammers, rivet busters, riveters, and drills. Where the old sheets had bursted new plates were substituted, but otherwise the old sheets were reused. The pneumatic tools were all furnished by the Chicago Pneumatic Tool Co., Chicago, Ill.



Damaged Oil Tanks Repaired With Pneumatic Tools.

## HEAT TRANSMISSION THROUGH GLASS AS USED IN BUILDING CONSTRUCTION.*

This apparatus consists of a wooden box, as shown in Fig. 1. The box is 6 ft. long, 4 ft. wide and 4 ft. high on the inside. The walls are 11 in. thick and are heavily insulated with wood, air space and cork. The cross section of the insulation is shown in Fig. 1. One side of the box may be removed and in this open side the different building materials may be constructed for test purposes. The box itself is on trunnions so that it may be turned in any position, enabling the material to be tested as a floor, as a wall or as a ceiling; it is also possible, as in case of roofing material, to place the box at any angle.

In order to determine the effect of rain on the coefficient of transmission, two rows of spray nozzles were arranged so that the material to be tested might be covered by a film of water. The effect of wind was determined by delivering air in a thin film across the surface of the material to be tested, the air velocity being produced by a blower driven by an electric motor. The air was delivered across the whole length of one side of the surface of the material to be tested.

The results of the tests made are given by Tables I, II and III. It is noted from the results shown that the heat transmitted is almost the same whether glass is used as a ceiling or as a wall, but when used as a floor there is a marked reduction in heat transmitted.

The second part of Table III gives some idea of what a large effect wind and rain have upon the coefficient of heat transmission. The rain increasing the heat transmission to a greater extent than the wind alone, most authors assuming the heat transmission through glass is 1 B.T.U. per square foot per degree difference of temperature and from these experiments we see that this corresponds to a condition of dry glass with a strong wind blowing. If we add to these conditions a heavy rain, the value of the coefficient is increased about 50 per cent.

While a rain never occurs in zero weather it is possible that a fine snow might occur at a very low temperatures. In this case the melting of the snow on the glass would give practically the effect of a wet glass at a very low outside temperature. It would seem therefore that the coefficient used for glass should be increased. The experiments show that this coefficient should be 1.48 or approximately 1.5. This would more nearly represent the maximum loss from glass than the coefficient 1, which is used at the present time.

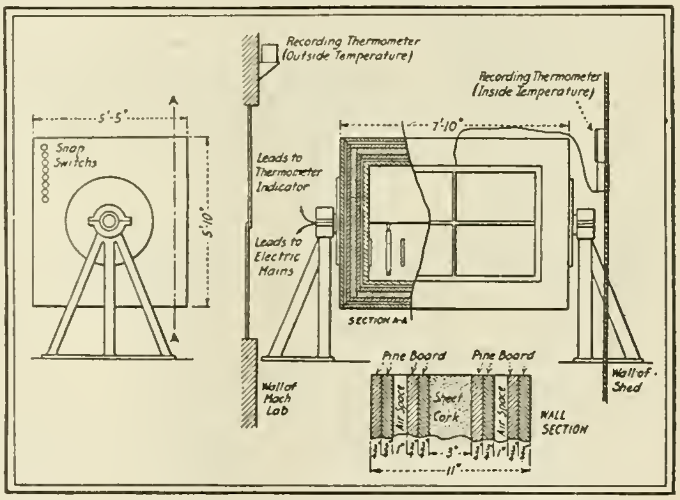


Fig. 1—Details of Construction of Apparatus for Testing Heat Transmission Through Glass.

The University of Michigan expects to carry on this line of experiments for a series of years. We shall next

TABLE I.—TESTS TO DETERMINE "K" FOR DIFFERENT POSITIONS OF THE GLASS.

| Test No. | 18 | 19 | 23 | 23 | 23 | 15 | 21 | 21 | 21 | 14 | 20 | 5 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Position | Glass in vertical position. | | | | | Glass as a ceiling. | | | | Glass as 45° skylight. | | Glass as a floor. | |
| Date, 1916 | 3/27 | 3/29 | 5/3 | 5/3 | 5/3 | 2/18 | 4/9 | 4/9 | 4/11 | 2/12 | 4/1 | 1/28 | 2/2 |
| Duration, hr. | 26 | 48 | 166 | | | 11½ | 52 | | | 9 | 96 | | |
| Instantaneous read. | | | | 8 a.m. | 8 p.m. | | | 6 a.m. | 10 a.m. | | | 1¼ | 2¼ |
| Average temperature inside | 89.2 | 22.2 | 139.3 | 128.2 | 131.2 | 72.1 | 85.7 | 80.2 | 87.2 | 75.1 | 91.6 | 76.2 | 78.7 |
| Average temperature outside | 40.4 | 44.6 | 56.7 | 45.2 | 50.2 | 14.5 | 40.7 | 33.2 | 41.2 | 13.1 | 42.6 | 29.7 | 18.7 |
| Temperature diff. | 48.8 | 47.6 | 82.6 | 83.0 | 81.0 | 57.6 | 45.0 | 47.0 | 46.0 | 62.0 | 49.0 | 46.5 | 60.0 |
| Watts | 354 | 328 | 566 | 566 | 566 | 382 | 310 | 310 | 310 | 388 | 313 | 263 | 386 |
| B.t.u. input | 1207 | 1119 | 1930 | 1930 | 1930 | 1305 | 1058 | 1058 | 1058 | 1323 | 1067 | 895 | 1313 |
| B.t.u. loss through wooden sides | 390 | 380 | 660 | 662 | 646 | 460 | 369 | 375 | 367 | 495 | 391 | 271 | 479 |
| B.t.u. loss through glass | 817 | 739 | 1270 | 1268 | 1284 | 845 | 689 | 683 | 691 | 828 | 676 | 524 | 834 |
| K | 0.698 | 0.647 | 0.640 | 0.637 | 0.660 | 0.611 | 0.638 | 0.606 | 0.626 | 0.557 | 0.575 | 0.470 | 0.579 |
| K corrected | 0.160 | 0.577 | 0.613 | | | | 0.525 | | | | | | |

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*Extract from paper by Prof. John R. Allen before the American Society of Heating and Ventilating Engineers.

TABLE II.—TESTS TO DETERMINE "K" FOR GLASS AS A WALL SUBJECTED TO RAIN AND WIND.

| Test No. | 24 | 24 | 26 | 26 | 26 | 26 | 28 | 28 | 29 | 29 | 30 | 31 | 31 | 33 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Condition | No. wind or water. | | | | | | | | Water. | | | Wind. | Water and wind. | | |
| Date, 1916 | 5/11 | 5/14 | 5/17 | 5/17 | 5/18 | 5/19 | 5/17 | 5/22 | 5/30 | 6/2 | 6/7 | 6/8 | 6/9 | 6/9 | 6/10 |
| Duration, hr. | 70 | | 48 | | | | 112 | | 120 | | 12 | 6 | | 48 | |
| Instantaneous reading | | 8 a.m. | | 6 p.m | 6 a.m. | 6 a.m. | | 6 a.m. | | 4 a.m. | | | 6 a.m. | | 6 a.m. |
| Avg. temperature inside | 135.8 | 133.2 | 117 | 116.2 | 119.2 | 128.7 | 122.1 | 128.7 | 106.7 | 105.7 | 108.6 | 96.7 | 95.2 | 94.2 | 92.2 |
| Avg. temperature outside | 55.7 | 51.2 | 46.2 | 47.2 | 42.2 | 47.2 | 50.4 | 54.2 | 62.9 | 61.2 | 58.5 | 54.7 | 54.2 | 55.8 | 54.2 |
| Temp. diff. | 80.1 | 82.0 | 70.8 | 69.0 | 74.0 | 72.0 | 71.1 | 74.5 | 43.8 | 44.5 | 50.1 | 42.0 | 41.0 | 38.4 | 38.0 |
| Watts | 574 | 554 | 481 | 481 | 481 | 481 | 481 | 481 | 481 | 481 | 481 | 481 | 481 | 481 | 481 |
| B.t.u. input | 1890 | 1890 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 | 1640 |
| B.t.u. loss through wood | 600 | 615 | 530 | 517 | 555 | 539 | 537 | 558 | 328 | 333 | 375 | 314 | 307 | 288 | 285 |
| B.t.u. loss through glass | 1290 | 1275 | 1110 | 1123 | 1085 | 1101 | 1103 | 1082 | 1312 | 1307 | 1265 | 1326 | 1333 | 1352 | 1355 |
| K | 0.671 | 0.647 | 0.654 | 0.678 | 0.611 | 0.637 | 0.641 | 0.005 | 1.248 | 1.222 | 1.05 | 1.315 | 1.355 | 1.468 | 1.485 |
| K corrected | 0.693 | | 0.657 | | | | 0.601 | | | | | | | | |

take up plate glass, then cement and other forms of building material.

TABLE III.—UPPER AND LOWER LIMITS, AND PROBABLE VALUE OF "K" FOR ALL TESTS.

I. Glass subject to ordinary atmospheric conditions and set in 10 inches from the face of the box.

| | Limits. | Probable value of "K." |
|---|---|---|
| Glass vertical | 0.577-0.660 | 0.630 |
| Glass horizontal on top | 0.525-0.638 | 0.610 |
| Glass inclined at 45 deg | 0.557-0.575 | 0.575 |
| Glass horizontal on bottom | 0.47 -0.479 | 0.47 |

II. Glass flush with the part of the box and subject to wind and rain.

| | Limits. | Probable value of "K." |
|---|---|---|
| Quiet conditions | 0.601-0.693 | 0.641 |
| Rain, no wind | ......... | 1.248 |
| Rain and wind | ......... | 1.485 |
| Wind blowing, no rain | ......... | 1.05 |

## OVERFLOW BRIDGES—TYPES OF OVERFLOW BRIDGES USED IN M'LENNAN COUNTY, TEXAS.

Contributed by William C. Davidson, Former Assistant County Engineer.

The overflow bridges herein described were built in McLennan County, Texas, during the years of 1914 and 1915. They were constructed as a part of a 175-mile system of concrete, macadam and gravel roads, built at a cost of $1,075,000.

In general the good roads system, though restricted to a road district, reached out to practically all the towns in the county. With Waco as a center seven main roads radiated out into the surrounding country. Lateral roads connecting the main pikes and short roads leading out from the smaller towns, completed the network of 175 miles of highway.

Frequently the roads traversed long stretches of overflow bottom lands along such streams as the Aquilla, Tehuacana, Bosque and other creeks tributary to the Brazos River. For obvious reasons, the building of a waterway of sufficient size to carry the flood water of such creeks was out of the question. Yet to have constructed a gravel or even a macadam road along sections subject to severe overflow would have been a wanton waste of material. A type of construction was needed that would withstand a swift current and perhaps several days of inundation.

The flood of 1913, during which the waters of the Brazos River and tributary streams reached almost an unprecedented flood stage, demonstrated the fact that to build the roads along these bottoms above high water was in some instances impossible and in practically all cases a matter of questionable judgment.

The plan finally adopted was to pave the overflow area with concrete and to span the main channel of the creek with a concrete bridge of the overflow type. The paramount idea in the design of such structures was to use a type of structure that would withstand the action of a heavy current, the possibility of drift lodging against the bridge and, when the flood had subsided, would leave the traveled roadway free from silt, mud and other flood deposits. It is the purpose of this article to discuss overflow bridges, dealing with the several types used throughout the system.

One of the main thoroughfares leading out of Waco is what is termed locally as the Waco-Marlin road. This road crosses the Tehuacana Creek, a stream much subject to overflow and back-water from the Brazos River. The type of bridge used is shown in an accompanying drawing designated as Fig. 1. The work was done under

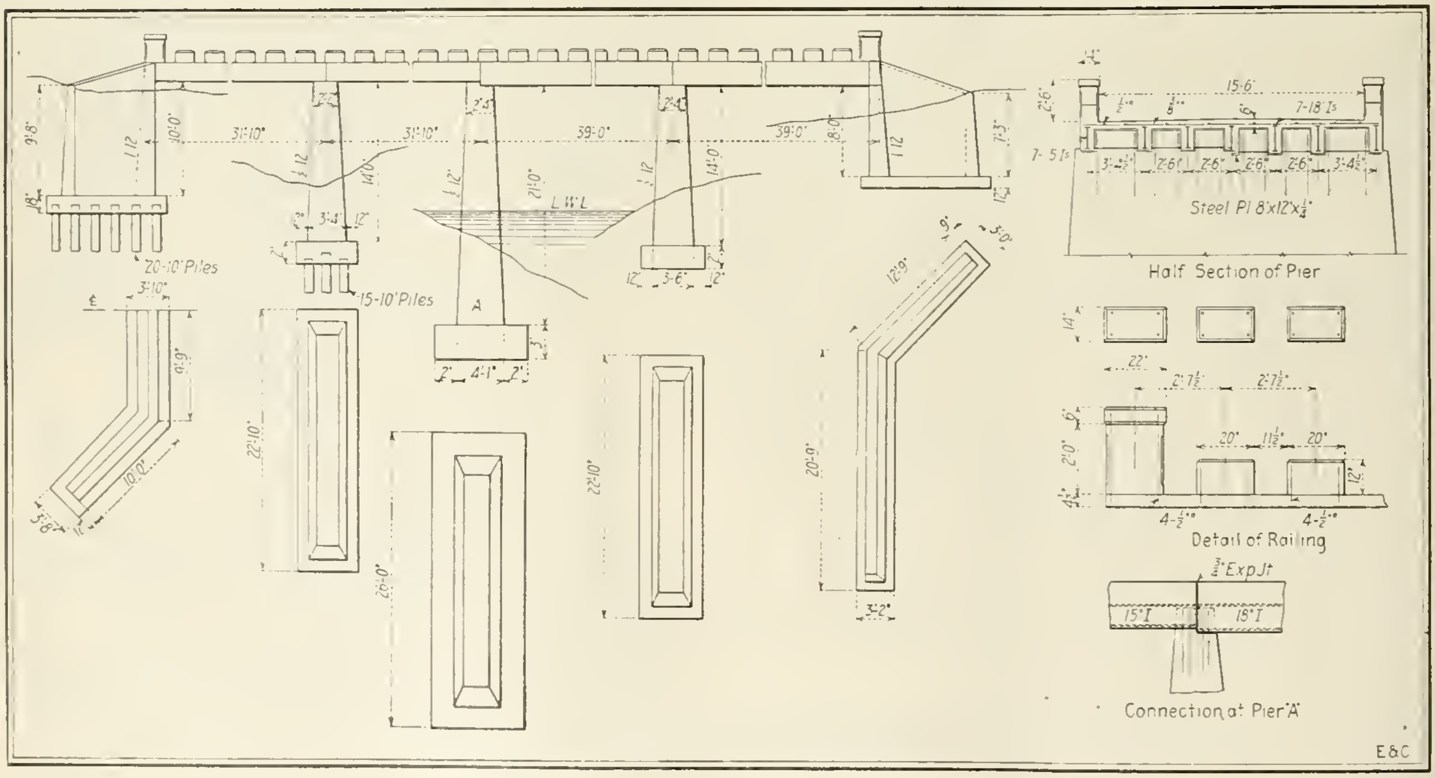


Fig. 1—Overflow Highway Bridge Over Tehuacana Creek.

contract with a unit classification and price for all materials and labor, with the exception of piling, which was handled as force account, the basis of payment being actual cost to the contractor for labor and materials plus 15 per cent. The itemized cost of this bridge follows:

| | |
|---|---|
| Wet excavation, 99.27 cu. yd. at $1.50 | $ 148.90 |
| Earth excavation, 149.2 cu. yd. at 40 ct | 59.68 |
| No. 1 concrete, 47.36 cu. yd. at $11 | 520.96 |
| No. 2 concrete, 222.47 cu. yd. at $10 | 2,224.70 |
| Reinforcing bars, 7,285 lb. at 3 ct | 218.55 |
| Steel I-beams, 48,652 lb. at 3 ct | 1,459.56 |
| Total | $4,632.45 |
| Pile Driving— | |
| Material for pile driver, including cost of 800-lb. hammer (no 15 per cent) | 48.18 |
| Labor on rig | 22.80 |
| Stripping and sharpening piling | 11.20 |
| Labor on driving piles | 81.90 |
| Plus 15 per cent | 17.39 |
| Total cost of driving piles | $ 181.47 |
| Grand total for structure | $4,813.92 |

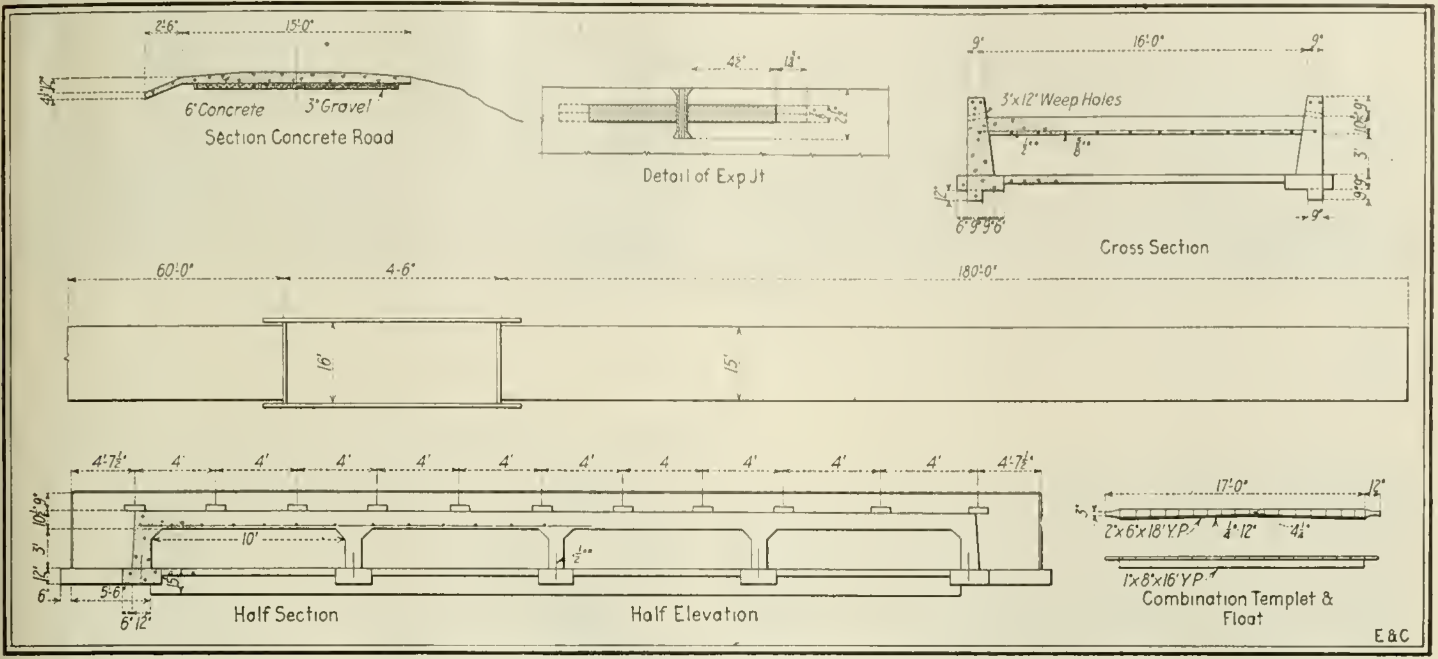


Fig. 2—Design for Overflow Bridge When Normal Flow Is Small.

The bridge was built during the latter part of the summer of 1915 when the water was at a low stage. One of the piers was situated in the middle of the channel where the water, even at low stage, was about 8 ft. deep. It was, therefore, necessary to construct a cofferdam. Wakefield piling was used in the construction of this cofferdam, with sacks of sand piled around the outside to prevent leakage. This pier was excavated to a depth of 12 ft. below the water level.

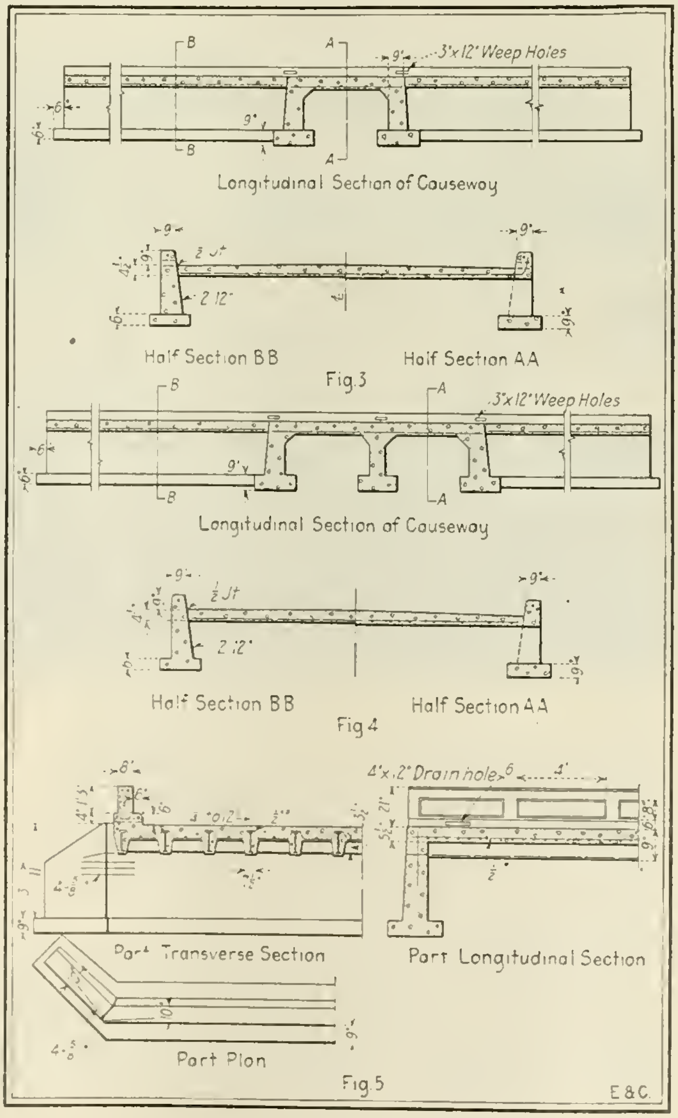
The following extracts from the specifications are given:

> Wet excavation shall consist of such excavation in the removal of which it shall be necessary to drive sheet piling and resort to continuous pumping.
>
> No. 1 concrete shall consist of one part of Portland cement and four parts of creek or bank run gravel, this class of concrete to be used for top slabs, posts and curb guards.
>
> No. 2 concrete shall consist of one part of Portland cement and six parts of creek or bank run gravel, this class of concrete to be used for the substructure, including abutments, wing walls, bottom slabs, footings and beam casings.
>
> The aggregate shall consist of a creek or bank run gravel which shall be free from earth, clay, loam or other impurities tending to weaken the concrete. It shall be uniformly graded in sizes varying from sharp sand to pebbles which shall pass a 1¼-inch screen.

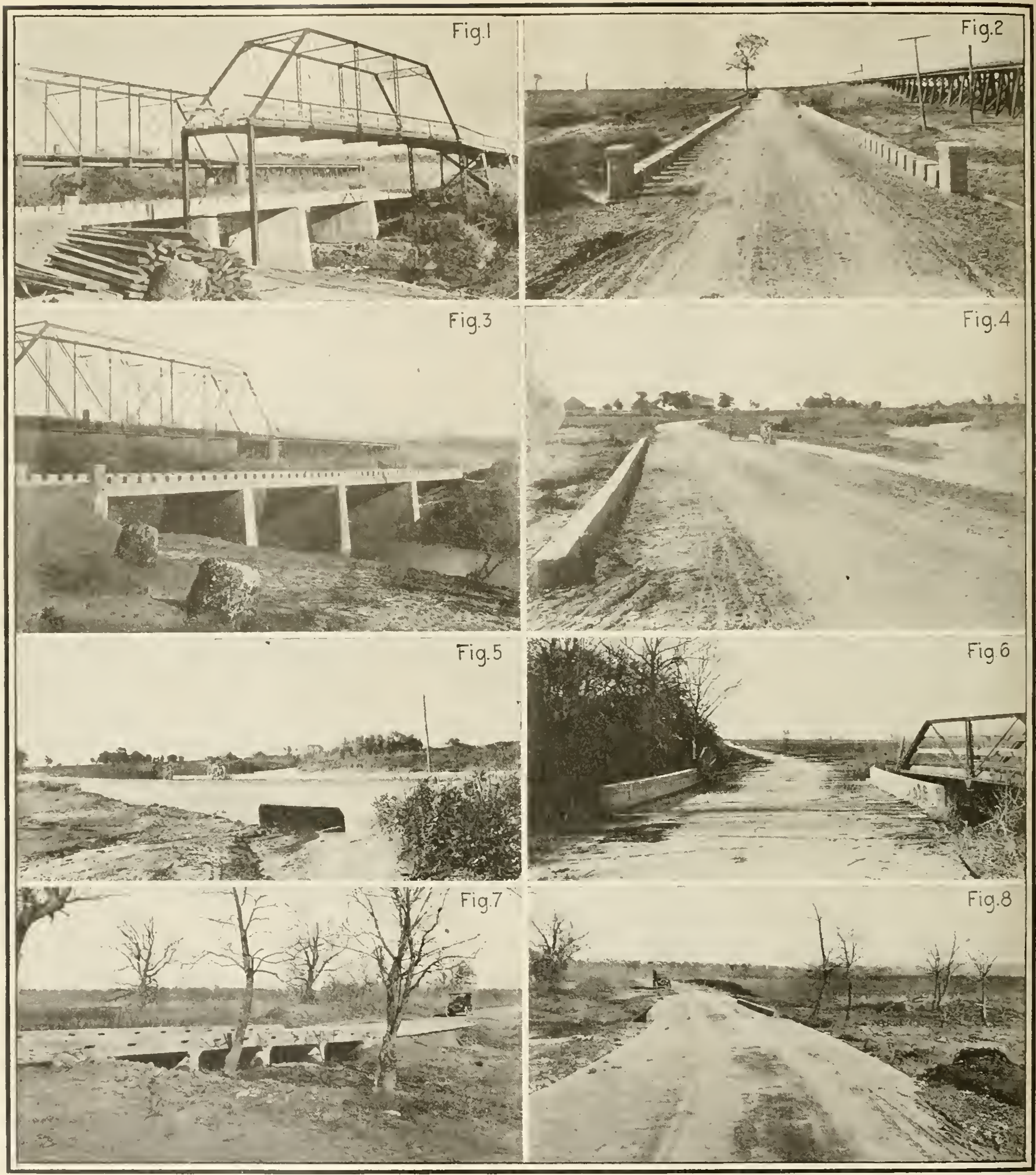
Wet excavation was paid for on the basis of the unit price for wet excavation plus the unit price for the material removed, according as it was classified as earth, loose rock or solid rock. The contractor used a 6-in. centrifugal pump driven by a gasoline engine to keep the water out of the cofferdam as the excavation progressed. A firm substrata of clay was secured for all foundations except in one pier and one abutment. In both of these a soft alluvial soil was encountered and it became necessary to drive a cedar pile foundation.

### Design Features.

The bridge consisted of two spans of 31 ft. 10 in., and two spans of 39 ft. The substructure of the bridge was plain concrete, while the superstructure consisted of steel I-beams encased in concrete, with a reinforced concrete floor. The bridge was designed for a live load of 150 lbs. per square foot, plus a deal load consisting of the steel beams carrying a concrete slab having an aver-



Figs. 3 to 5—Types of Overflow Bridges.



Figs. 1 to 8—Views of Overflow Bridge Construction in McLennan County, Texas.

age thickness of 5¼ in. In addition to this there was the dead load due to the beam encasements.

Its location was such that the central pier fell in the middle of the channel. The floor elevation was some 10 ft. below high water level as given by the flood of 1913. In adopting this elevation for the bridge floor due regard was given to the drift line of the stream, the object being to place the structure at such an elevation that the danger of drift lodging against the bridge would be eliminated. To further insure the bridge from damage due to drift, the usual handrailing feature was omitted. In its place were substituted pedestals 12 in. high by 20 in. long with a space of 11½ in. between them. At each end of the bridge a large pedestal 12 in. x 20 in. x 2 ft. 6 in. was used in place of the short pedestal. This large pedestal merely served an ornamental purpose. The purpose of using pedestals of this design was to provide a wheel guard for vehicles, and at the same time not offer an obstruction to drift nor collect silt or mud upon the floor of the bridge. It can readily be seen that this design of pedestal will enable the current to keep the floor washed free of silt and mud.

The superstructure was securely anchored to all piers and abutments with reinforcing bars extending into the concrete of the substructure. Expansion joints were placed at points as indicated on the general drawing. All piers were of plain concrete with batters of ½ in. in 12 in. on the sides and 1 in. in 12 in. on the ends. Abutments and wing walls were also of plain concrete, and were constructed vertical on the face and battered 1 in. in 12 in. on the back.

### Old Span.

The new structure, having a total length of 141 ft. 8 in., replaced an old steel and timber trestle bridge whose total length was 233 ft. The old bridge had a central span of steel, 80 ft. long, and 153 ft. of timber trestle approach. The floor elevation of the old bridge was 13 ft. above the floor elevation of the new structure. Therefore by the use of an overflow bridge, there was a saving in length of bridge of 91 ft. 4 in. as well as a saving in height of piers.

It is only expected that this waterway will provide for the normal flow of the stream. Occasionally the bridge will be covered with flood water, during which time traffic will be suspended. For several hundred feet on each end of the bridge concrete road has been built. This will prevent the washing away of the earth approaches. During a recent flood the floor of the new bridge was covered with water to a depth of 5 ft. and traffic was suspended for several hours. No damage was done to the bridge and very little silt collected on the roadway, thus demonstrating the usefulness of the open design pedestal.

### Overflow Bridge for Small Waterway.

In general two types of overflow bridge were employed throughout the system. The type previously described is applicable to large streams, while the one now under discussion applies more particularly to small overflow areas.

Figure 2 represents a design where the normal flow of the stream is small, in fact in the case described, there is no flow except during a flood period. The channel is a slough which is fed from the overflow waters of Aquilla Creek. From three to four times a year this creek overflows its banks and spreads over the adjacent bottom lands. When it reaches a depth of 4 ft. over the bottoms the water breaks through the slough in question, forming a raging torrent about 300 ft. wide. As a result traffic was formerly suspended for as long as two or three days at a time. Such was the velocity of the current that it was dangerous for a vehicle to attempt to cross when the depth of the water exceeded 1 ft.

It became necessary to bridge or pave the entire overflow width of the road in order that the construction be of a permanent nature. The design adopted consisted of a series of concrete boxes for the central part of the channel, with a concrete pavement at each end of the culvert to extend to the edge of the overflow area. The bridge proper consisted of four 10-ft. boxes having a clear height of 3 ft. and a width of roadway of 16 ft. The remainder of the channel, consisting of 240 ft., was paved with concrete. The down-stream side of the concrete road was provided with an apron 2½ ft. wide, to prevent a back wash under the pavement.

To insure against the possibility of sliding on the base, the side walls and piers were securely anchored to the footings with reinforcing bars. The footings themselves were extended well below the surface, and to guard against wash and underflow of water, toe walls were used on both the upstream and down-stream ends. As shown on the drawing, weep holes, 3 in. x 12 in., spaced 4 ft. on centers on both curb guards, were provided to prevent mud from collecting on the floor of the bridge during an overflow. A recent overflow demonstrated the fact that these weep holes will serve every purpose for which they were intended. The different classes of concrete used in the bridge, were subject to the specifications herein mentioned.

The concrete road had a width of 15 ft. exclusive of the 2½-ft. apron on the down-stream side of the pavement. Its thickness at the center was 6 in. and at the sides 4½ in. Expansion joints were placed every 30 ft. apart. A detail of the joint is shown in Fig. 2, and consists of two metal bars securely anchored to the concrete on either side of the section, with an elastite filler between. The filler used was two thicknesses of rubberoid roofing. The specifications for the concrete called for a mixture of 1:2:3½. This gave on an average of 48 bags for each 30-ft. section. The roadway was crowned at the rate of ¼ in. per foot, or a total crown in 15 ft. of 1⅞ ins. A template used in obtaining this crown is shown in Fig. 2. It was so constructed that it could be used both as a template and as a float for the concrete.

The work of building both the culvert and the concrete road was done under the direct supervision of the county engineer. Labor was employed at the following figures, on the basis of an 8-hour day:

| | |
|---|---|
| Foreman, per day | $4.00 |
| Form builder, per day | 3.00 |
| Common labor, per day | 1.50 to 1.75 |
| Teams, per hour | .40 |

### Cost of Culvert.

The figures which follow represent actual cost to the county:

| | |
|---|---|
| Earth excavation (hand labor) | $ 8.30 |
| Earth excavation (team labor) | 8.80 |
| Foreman | 4.00 |
| Total cost of excavation | $ 21.10 |
| Total cu. yd. of excavation, 94. | |
| Cost per cu. yd | $ .22 |
| Mixing and pouring concrete | 70.40 |
| Foreman | 20.00 |
| Form work | 34.15 |
| Foreman | 8.00 |
| Hauling water for concrete | 6.80 |
| Total labor cost | $157.45 |

There was a total of 62.63 cu. yd. of concrete used in the culvert, from which the following unit costs for labor are deduced:

| | |
|---|---|
| Pouring concrete, per cu. yd | $1.44 |
| Form building, per cu. yd | .68 |
| Water for concrete, per cu. yd | .11 |

The foundation excavation was practically all done with team and fresno, and consequently the labor cost was very much lower than usual for such work.

The unit cost on forms also included the placing of 2,830 lb. of reinforcement. There were used in the bridge 200 sacks of cement at a cost of $0.42 per sack net; and at a cost of 6⅔ ct. per sack for hauling a distance of four miles from the railroad to the bridge site, making a total cost of 48⅔ ct. per sack. A total of 69½ cu. yd. of gravel were used at a total cost of $59.01 at the site, or a unit cost of 85 ct. per cubic yard. The haul distance was 2½ miles. The gravel used was pit run, costing 10 ct. per cubic yard at the pit, with a price of 75 ct. per cubic yard for hauling. A total of 3,160 ft. of form lumber was used. This cost at the site $103.58, including the haul on same. Therefore the cost per cubic yard of concrete for forms was $1.65. Other miscellaneous costs follow: V-strips, 350 lin. ft., $2.63; one keg of 6d common nails, $2.75; one 100-lb. roll of No. 9 wire, $3.20.

To summarize, we have a total cost of bridge exclusive of foundation excavation and reinforcing bars, as follows:

| | |
|---|---|
| Mixing and pouring concrete | $ 90.40 |
| Forms | 145.73 |
| Cement | 97.32 |
| Gravel | 59.01 |
| Water | 6.80 |
| V-strips | 2.63 |
| Nails | 2.75 |
| Roll of No. 9 wire | 3.20 |
| Total cost | $407.84 |
| Cost per cu. yd. of concrete | 6.51 |
| Cost of Concrete Road— | |
| Preparation of trench | $ 40.20 |
| Form lumber | 3.00 |
| Labor on forms | 3.75 |
| Miscellaneous tools | 21.08 |
| Gravel | 117.45 |
| Screening gravel | 9.75 |
| Hauling water for concrete | 18.20 |
| Miscellaneous hauling | 2.00 |
| Cement | 175.14 |
| Hauling cement | 28.20 |
| Mixing and pouring concrete | 51.95 |
| Miscellaneous (bundling sacks, etc.) | 3.45 |
| Foreman | 32.00 |
| Total cost | $506.17 |

There was a total of 506 sq. yd. of pavement, including the surfacing of the top slab. Hence the cost per square yard was approximately $1.

The cement was hauled a distance of four miles at a cost of 6⅔ ct. for hauling and a cost of 42 ct. net for the cement, making a total cost per sack at the site of 48⅔ ct. Water used in the mixing of the concrete was obtained within 100 yards of the site from a pond. It was hauled in barrels with team labor at 40 ct. per hour. The cost of water per square yard of concrete was 3.6 ct. In the preparation of the channel both team and hand labor was employed. The total cost of this item was $40.20, with a cost of 8 ct. per square yard of concrete. This item of cost included everything necessary to put the trench in condition to receive the concrete.

Gravel at the site cost $1.35 per cubic yard, of which $1.25 was for a haul of $4\frac{1}{2}$ miles and 10 ct. for the cost of the gravel at the pit. A total of 87 cu. yd. were used, with a resultant cubic yardage of concrete of 74.5. Upon this basis the shrinkage in the gravel was 17 per cent. The total cost of the gravel at the site, including the cost of screening a portion for the top slab of the culvert, was $127.20. Therefore the cost per square yard of concrete was 25 ct.

The expansion bars used were patented and cost $1 per bar f.o.b. Waco, Tex. Since two bars were required at each joint, the cost of same was, therefore, $2, exclusive of the elastite filler. This cost roughly 15 ct. per joint.

Figure 3 shows a general standard employed for another type of overflow bridge. This type is very similar to the one just described and is applicable to drainage areas where the normal flow is small. If more than one opening is desired, a standard as shown in Fig. 4 may be used.

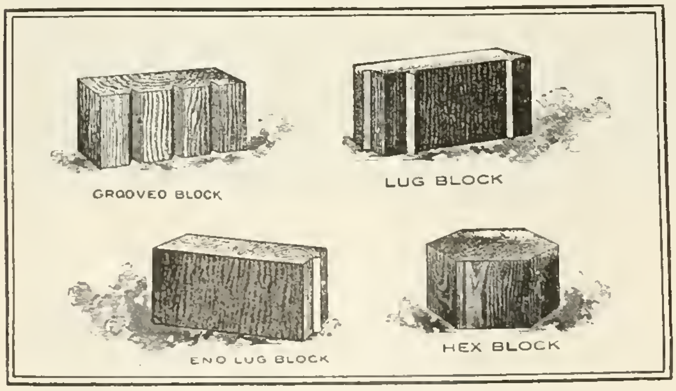
Figure 5 shows a standard plan for an overflow bridge of the I-beam type. This structure consists merely of an encased I-beam of one or more spans as desired, with a low, massive railing wall which will offer as little resistance as possible to water and drift.

### Personnel.

The foregoing construction work and design was carried out under the direction of Rollen J. Windrow, Chief Engineer of the $1,075,000 road system. As an assistant to Mr. Windrow the writer had active charge of the work herein described. The McCall-Moore Engineering Co. of Waco, Tex., had the general contract for the bridge and culvert work, which included the bridges discussed in this article, with the exception of the one mentioned as being under the direct supervision of the engineer.

## SPECIAL WOOD BLOCK DESIGN FOR MILL FLOORS.

When heavy metal products are piled on and handled over mill floors wood block construction presents marked merits. In the four illustrations reproduced here are shown wood blocks of special design for factory floors. As shown all blocks are laid with the end of the grain forming the wearing surface. All blocks are sterilized and preshrunk and are given the kreolite oil treatment. In other respects the blocks are varied to suit varying conditions of use. The lug blocks are manufactured with two V-shaped lugs or beads on one side and one on the end. These lugs extend to the depth of the block in the direction of the grain. The end lug block is manufactured with one lug on one end of each block extending the full depth in the direction of the grain. Grooved blocks have three V-shaped grooves on one side of the block running the depth of the block in the direction of the grain, breaking the continuity of the largest annual rings. Hex blocks are manufactured from air seasoned slow growth, fine grained tamarack logs, hexagonal in shape; are either 5 or 6 in. across the face and vary in depth from 2 to $3\frac{1}{2}$ in. The blocks for any one job are made of uniform depth and width.

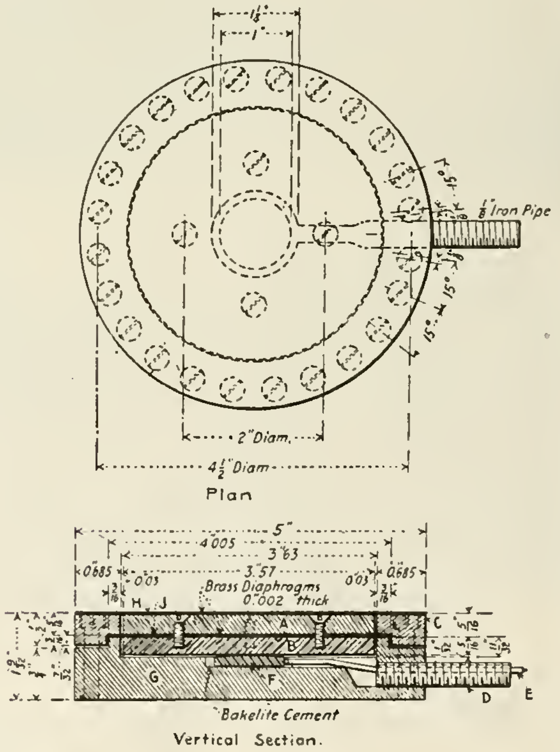


Wood Blocks for Factory Flooring.

Lug or hex blocks are used in floors where there will be much moisture. Both types of block absorb all expansion automatically, eliminating any danger of the floor bulging. Either hex or grooved blocks are used where there is much dry heat and where there is a tendency for the blocks to dry out and shrink. Hex blocks are suitable for such places because they are manufactured from all heart wood, and on account of their shape take all radial contraction, which is very slight. Grooved blocks, because of the three V-shaped grooves on one side of the block, breaking the continuity of the largest annual rings, eliminate shrinking, acting on the same principle as grooves in maple or oak strip flooring. The manufacturers are the Jennison-Wright Co., Toledo, Ohio.

## A SOIL PRESSURE MEASURING DEVICE.*

A device is illustrated which can be used for measuring earth pressures, the pressure of concrete against forms and the pressure of grain and other materials in bins. A cast-iron base G is fitted with a brass diaphragm J, held in place by the annular ring C. On each side of this diaphragm are disks, A and B, securely and rigidly held together by means of Bakelite cement and machine screws, as shown. These plates have an annular clearance from the ring C of 0.03 in., thus allowing only a small annular portion of the diaphragm J to be the flexible element. The diaphragm H serves the double purpose of protection and of stiffening the plates A and B against side motion and eccentric loads. In the base G is placed a slightly crowned support F, held in place and electrically insulated from the base by Bakelite cement. An insulated



Plan

Vertical Section.

Device for Determining Soil Pressures.

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*Extract from a paper by A. T. Goldbeck and E. B. Smith before the American Society for Testing Materials.

bell wire E is soldered to the support F, and passes to the outside connections through the ⅛-in. pipe D.

In the use of this apparatus the cell is buried in the soil to the required depth, and, by means of the ⅛-in. pipe and the bell wire, is connected to the remote control and indicating instruments. Air pressure is slowly admitted from a compressed-air supply until the air pressure within the cell equilibrates the external pressure on the disk A, and causes the contact between disk B and support F to be broken, as indicated by an ammeter or a telephone receiver. Very careful calibration tests have demonstrated the reliability of the instrument.

It is intended to bury a number of these cells in a horizontal or vertical position within earth fills, the piping from each cell being brought to some convenient position where readings may be taken at any time. One set of indicating and controlling instruments mounted in a convenient carrying case is all that is necessary for reading any number of pressure cells. The cost of each cell when made in lots of ten should be about $15, and the cost of one complete indicating and control apparatus without a case should not exceed $40.

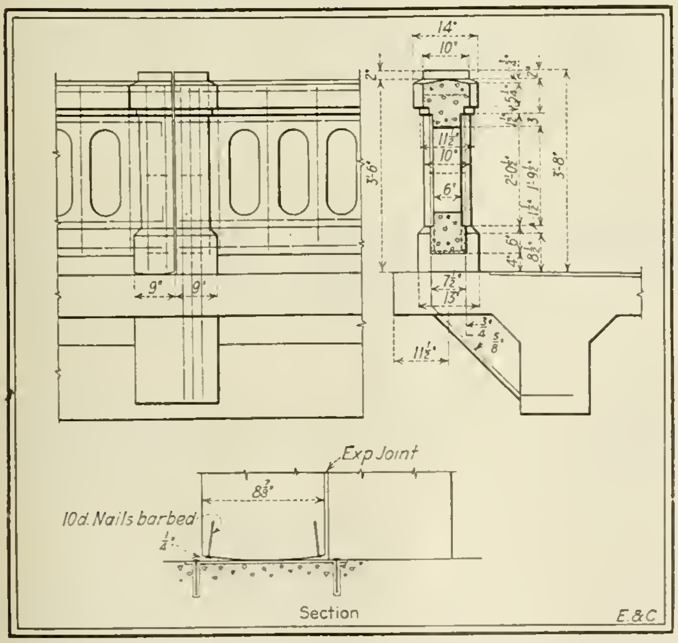
There are a number of uses to which the apparatus may be adapted besides that of measuring earth pressures. Thus, the pressure of concrete in forms may be determined very readily, that of ensilage in silos, the pressure of various finely divided solids in bins, and that of any material which may be slightly compressed without an appreciable increase in the pressure exerted against the instrument.

## EXPANSION JOINT CONSTRUCTION FOR CONCRETE BRIDGE RAILING.

Contributed by Charles W. Martin, Engineer Bridge Division, St. Louis, Mo.

The Columbia Avenue Bridge, St. Louis, Mo., is a reinforced concrete structure of the slab and stringer type crossing over the tracks of the Missouri Pacific Ry. At the abutments, the stringers of the end spans are furnished with cast steel shoes and bed plates which were designed to take care of movements generated by temperature changes in the deck. The sidewalks on each side of the bridge roadway are flanked by concrete railings. Some of the details of this railing are novel.

The railing was made as a system of pre-cast unit panels anchored into cast in place posts. Crushed granite was used as the aggregate. Each panel unit consists of longitudinally reinforced upper and lower flanges and a vertically reinforced web with close-spaced openings. The panel units were cast flat and seasoned near the bridge. When two days old they were turned up on edge and given a scrubbed finish with acid. They were pushed to place on rollers and assembled on wedges. The post forms were then built about their ends.



Expansion Joint for Bridge Railing.

The posts at one end of each of the four railing panels, which span over the expansion joint between the deck structure and the abutment, are split vertically and the bottom of the movable half is provided with a curved base sheathed with copper which slides on a copper base plate anchored to the sidewalk slab. A detail of this is shown by the illustration.

The construction of these split posts was quite simple. The first half was cast about the end of the panel unit which it adjoined. The joint surface of this half was then coated with parafline and the movable half cast against it. When seasoned the movable half and the panel unit anchored into it were slid forward about ⅜ in. and the intermediate posts then constructed. The bridge and railing were built under the direction of the Bridge Division of the President's Department, City of St. Louis. E. R. Kinsey is President of the Board of Public Service, L. R. Bowen is Bridge Engineer. The writer designed the structure and was in charge, in the field, of the construction. The contract price for the railing amounted to $1.70 per lin. ft., including the posts. At that price the profit, if any, was small.

## TEST OF CONCRETE FLOOR I-BEAM ROAD BRIDGE, MINNESOTA STANDARDS.*

The 1913 session of the Minnesota State Legislature changed the law so as to require an 18-ft. roadway for practically all bridges, and a law was also passed requiring that all bridges built after the passage of the bill should be made safe for a twenty-ton traction engine with three-fourths of the load on one axle.

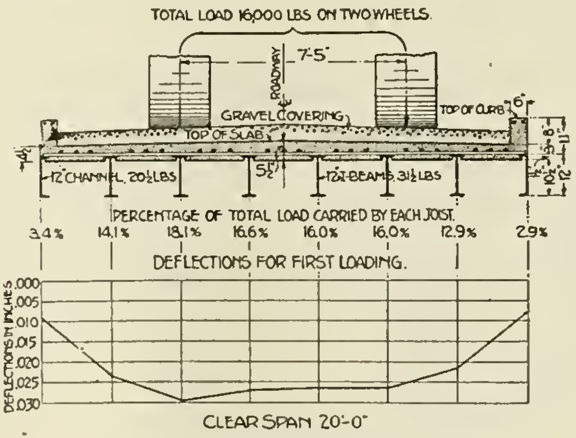


FIG 1.

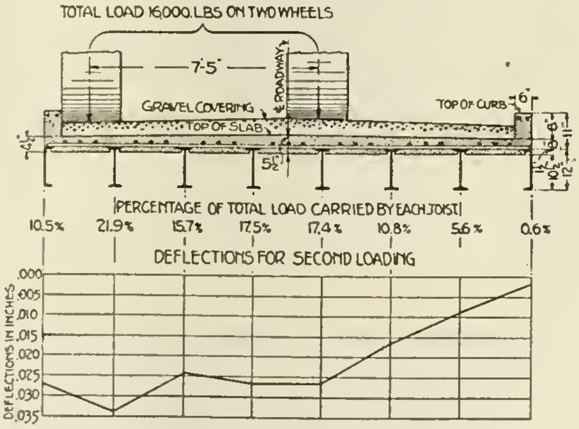


FIG 2

Figs. 1 and 2—Concrete Floor I-Beam Road Bridge.

Before revising the standard plans of the Highway Commission it was necessary to determine the distribution obtained with the standard concrete floor slabs.

A test was made of a 20-ft. clear span 16-ft. roadway bridge having six lines of 12-in. I's and two lines of 12-in. channels.

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*From the July Journal of the Minnesota State Highway Commission, St. Paul, Minn.

The floor was 5½ in. thick at the center and 4½ in. thick at the sides, reinforced with ½-in. square twisted bars placed transversely and spaced 6 in. apart with three longitudinal bars of the same kind in each space between the beams.

Figure 1 sows the deflections of each beam with the rear wheels of the traction engine at the middle of the span, and in the middle of the roadway. It also shows the per cent of the total load which was carried by each joist. Figure 2 gives the same information for the loading with the traction engine over against the curb, and at the middle of the span.

The test showed that no beam carried to exceed 21.9 per cent of the total load and that it would be safe to increase the roadway to 18 ft. without adding another joist, as the load would be no greater and the joists would only be 3½ in. farther apart.

This has resulted in quite a saving in cost on several hundred bridges for which we have furnished plans since the test.

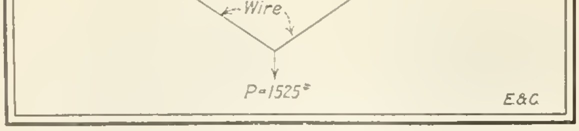
It will be noted in Fig. 2 that the third joist from the left-hand side and midway between the wheels did not deflect as much as those on each side of it giving tension in the top of the slab.

The tie rods between the outside joists in the new standard beam spans supplies the reinforcing that is necessary in the top of the slab to provide for this tension.

With plank floors the load is not so well distributed, and each joist has to be capable of carrying a much larger per cent of the load. Consequently the same size joists are necessary under a wood floor as under a concrete floor even though the planks weigh less than the concrete slab, and as the spacing would be too great if the joists were more than 2 ft. apart, with a plank floor, it is necessary to use one extra line of joist when the roadway is increased to 18 ft.

## VITRIFIED TILE UNDERFLOOR PROTECTION FOR CONCRETE BRIDGES.

A concrete bridge of the Boston & Albany R. R. crossing the tracks of the New York, New Haven & Hartford R. R. at Worcester, Mass., has its underfloor surface only 3 ft. above the stacks of locomotives passing underneath protected by vitrified tile facing. The tile used are indicated by the illustration, which gives all essential dimensions. Preparatory to using this facing test blocks were made, as illustrated. At a load of 1,525 lb. the blocks broke along the line AA, the concrete being nine days old. While, owing to the location of the rod BB, to which the load was hung, the test was not a true determination of the adhesion of the tile, it gave a sufficient indication of this quality to demonstrate that tile so used could be depended upon to remain fast under normal circumstances. The information quoted is given by F. B. Freeman, Chief Engineer, Boston & Albany R. R., Boston, Mass.



Tile Casing for Underfloor of Concrete Bridge.

## FORMULA FOR MAXIMUM MOMENT IN THE SIDE WALLS OF BOX CULVERTS.

Contributed by Walter S. Todd, Junior Engineer, Illinois Highway Department, Springfield, Ill.

The following approximate formula has been used by the Bureau of Bridges of the Illinois Highway Department to determine the maximum moment in the side walls of box culverts in order to simplify the computation. It is assumed that the horizontal thrust due to the earth fill is equal to that of a fluid weighing p pounds per cubic foot. The wall is assumed to be a simple vertical beam with a span equal to the clearance, $h_1$ (Fig. 1).

The load varies uniformly from a minimum of $ph_2$ at the upper end of the beam, as shown by cd, to a maximum of ph at the lower end, as shown by ae. This trapezoidal load diagram is divided into the rectangular area bcde, and the triangular area abc.

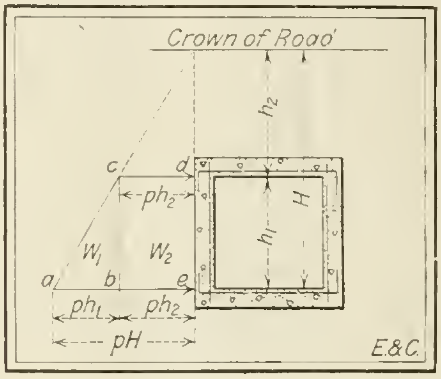


Fig. 1.

If $W_1$ is equal to the area abc, and $W_2$ is equal to the area bcde, then the maximum moment due to the former is equal to $\frac{104}{810} W_1 h_1$, and the maximum moment due to the latter is $\frac{1}{8} W_2 h_1$.

$$\text{Combining, } M = \frac{1}{8} W_2 h_1 + \frac{104}{810} W_1 h_1.$$

$$W_1 = \frac{ph_1^2}{2}, \text{ and } W_2 = ph_2 h_1.$$

Substituting these values of $W_1$ and $W_2$ above and reducing to inch-pounds,—

$$M = (\frac{1}{8} ph_2 h_1^2)\ 12 + (\frac{104}{810} \frac{ph_1^3}{2})\ 12.$$

Simplifying, $M = (1.5\ h_2 + 0.77\ h_1)\ ph_1^2$ inch-pounds with $h_1$ and $h_2$ expressed in feet. Using a value of 15 pounds per cubic foot for p, the formula becomes,—

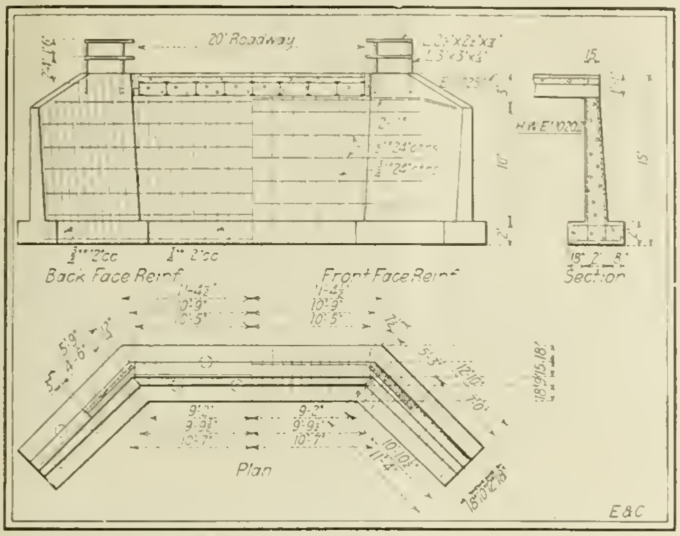
$M = (22.5\ h_2 + 11.55\ h_1)\ h_1^2$ which is the formula used in the design of culverts by the Bureau of Bridges. Using a value of 21 pounds per cubic foot for p, the formula is $M = (31.5\ h_2 + 16.17\ h_1)\ h_1^2$.

The results obtained by the use of this formula are slightly in excess of those obtained by the exact method; but in the majority of cases met in the design of highway culverts these results do not exceed the exact calculation by more than 1 per cent. The clearance seldom exceeds 12 ft., so that it seems logical to neglect the column action due to the weight of the slab and the earth fill above the slab.

This formula also applies to the vertical beam between the footing and superstructure in the abutment walls of slab bridges.

## COST OF I-BEAM HIGHWAY BRIDGES IN BOONE COUNTY, IOWA.

Following standard plans of the Iowa State Highway Commission, there have been built and are under contract in Boone County, Iowa, a number of T-beam, concrete-floored bridges of interest. The drawings present a representative structure having a clear span of 32 ft., and give most of the essential details. The floor slab is 6-in. thick and its bottom is 1 in. below the tops of the joists. It has, as will be noticed, a curb at each side to hold the roadway fill of gravel. The spaces between T-beams over the abutments are filled with concrete laid on a 3-thickness tar paper covering of the abutment top, this construction affording an expansion joint. The costs of several bridges of this type are given by County Engineer J. A. Illman, Boone,, Iowa, as follows:



Highway Bridge Details, Boone County, Iowa.

|  | Cost. |
|---|---|
| 25-ft. I-beam, 22½ ft. clear span, 18-ft. roadway | $1,269.12 |
| 25-ft. I-beam 22½ ft. clear span, 18-ft. roadway | 1,254.97 |
| 32½-ft. I-beam, 30 ft. clear span, 18-ft. roadway | 1,348.93 |
| 34½-ft. I-beam, 32 ft. clear span, 18-ft. roadway | 2,049.00 |
| 22½-ft. I-beam, 20 ft. clear span, 18-ft. roadway | 1,360.00 |
| 24½-ft. I-beam, 22 ft. clear span, 18-ft. roadway | 2,014.00 |

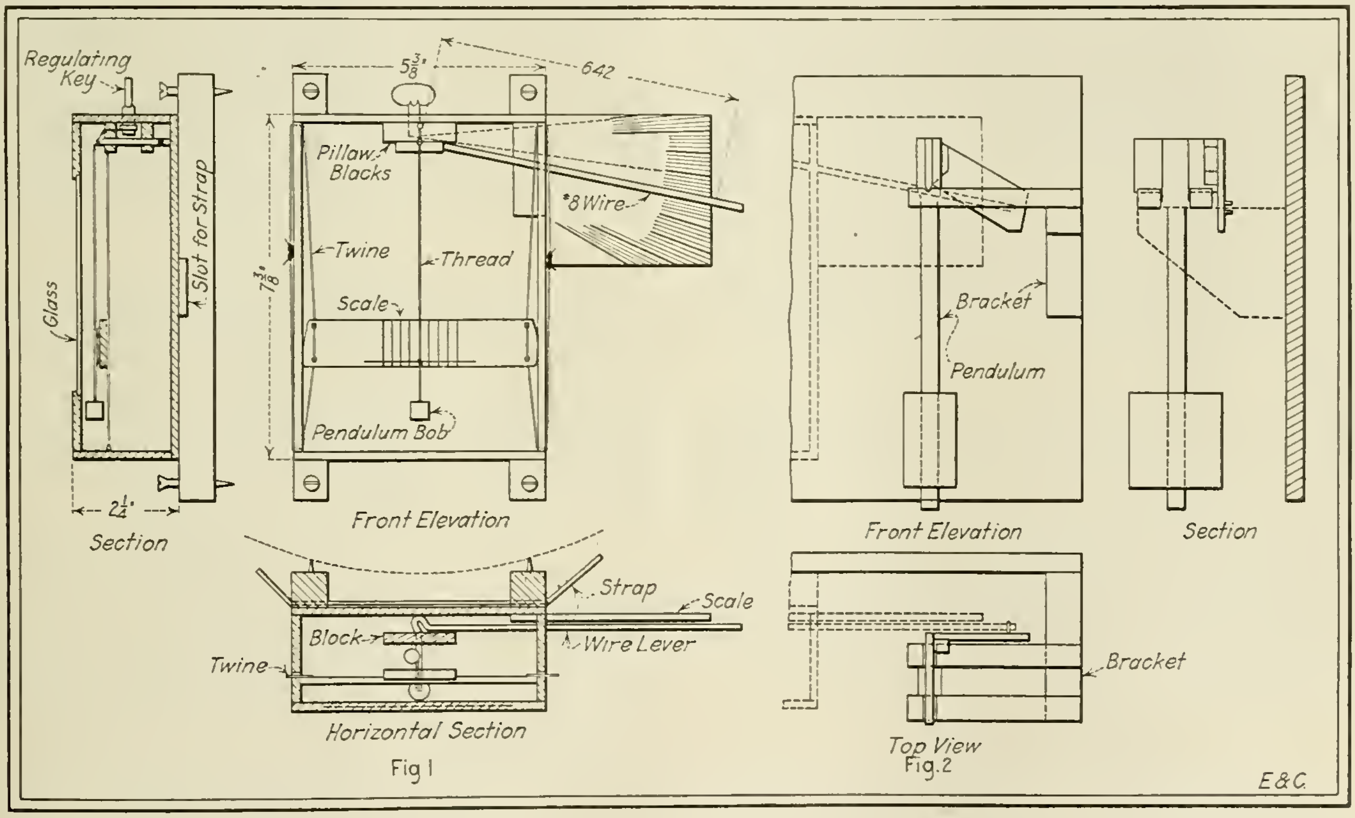
The first three items were put in by the county's bridge crew last year, while the other three are under construction now. The last three were let by contract and the price shown was the contract bid. The prices do not include piling.

## APPARATUS AND METHODS USED IN MEASURING THE VIBRATIONS IN A BUILDING.*

The owner of a business building in St. Paul recently asked for an opinion as to whether the installation of certain machinery, with heavy reciprocating parts, would cause injurious vibration. The building in question is about 100x140 ft. in plan and seven stories high. It is of substantial, reinforced concrete construction, designed for warehouse loads. To predict, by calculation, what the vibrations would amount to in such a building is impossible. The conditions are too complex. Taking into consideration the small mass of the machines, as compared to that of the building, it seemed safe to expect that internal friction in an elastic structure of this character would convert sufficient energy into heat to prevent the vibrations from reaching a dangerous magnitude. Upon this basis, an opinion favorable to the installation was given.

Shortly after the plant was put in operation there was complaint of excessive vibration. "The building is swaying pretty near an inch"; "It shook some work off of a lathe"; "The water tower on the roof is swaying like a palm leaf fan at a circus"; and many other such comments were reported. Opposed to such statements, the mere opinion of an engineer could have no force; therefore some sort of measurements must be made.

After considering several possible devices, the idea for apparatus No. 1 (see Fig. 1) as shown was adopted as offering the fewest difficulties in construction, and consequently the smallest probability of error in the results. The apparatus is built in a cigar box and consists of a small pendulum suspended from a notch in the beveled end of a No. 8 wire. This bevel and notch locates the point of suspension of the pendulum at the lower end of the wire, or .0643 in. from its center. A portion of the wire is bent to the right, forming a lever about 7 in. long. When the end of this lever (at 6.43-in. radius) is moved 0.1 in., the point of suspension of the pendulum moves 0.001 in. The motion of the lever can be gaged by the scale shown. A scale for reading the length and one for reading the width of the swing of the pendulum are also provided.



Figs. 1 and 2. Apparatus for Measuring Vibrations in Building.

The apparatus was attached to a column in the building, where a measurement was desired, and the pendulum was adjusted in length so that it had the same number of vibrations per minute as the building. It would then respond to the motion of the building, and when it appeared to have reached a definite, unvarying swing, the amplitude and length were recorded. A number of observations of this kind were taken covering a total time of about 15 hours. The apparatus was then attached to a motionless support. The pendulum was given a good start and a count was made of the number of swings required for it to lose one division of the scale in deflection at the amplitude of each observation at the building. By a simple proportion the amplitude lost in each beat (half vibration) could be figured. This was the amount of the motion added in each beat, by the building, to maintain the swing noted. Following is the record and calculation of the maximum observed motion:

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*Paper by P. E. Stevens, Consulting Engineer, in Bulletin of the Civil Engineers' Society of St. Paul.

OBSERVATION NO. 8.

At Building.

| | |
|---|---|
| Machines running | 4 |
| Frequency | 93 per minute |
| Pendulum | 10.2 cm. long |
| Swing read at | 5.8 cm. radius |
| Amplitude of swing | 3.8 cm. |

At Office.

Subsides from 4.0 cm. to 3.8 cm. in. 19 vibrations
Subsides from 3.8 cm. to 3.6 cm. in 21 vibrations

Average of 10 counts .............. 20 vibrations

To lose 2 mm. in amplitude, or 1 mm. in amplitude in 20 beats ........ 0.0394 in.
1 mm. ÷ 20 = 0.00197 in.
0.00197 in. at 5.8 radius is 0.0063 in. at 10.2 radius.

Therefore 0.0063 in. is amplitude of motion added each beat, or the amplitude of vibration of building.

With these calculated vibrations as a guide, the lever was then operated so as to reproduce the motion of the building at the point of suspension of the pendulum. The swinging of the pendulum thus induced corresponded fairly well with that observed at the building. Moving the lever by hand, however, was not very satisfactory, and in order to get real corroboration of the calculated amplitude of vibration, apparatus No. 2 (see Fig. 2) was made. A pendulum, with an adjustable bob of about 2 lb. weight, has an arm extending to the right from its upper end. Pins on the arm engage the lever of apparatus No. 1 and communicate to it the motion of the heavy pendulum. By this means the point of suspension of the small pendulum can be given a motion agreeing exactly with the calculated swaying of the building. Using apparatus No. 2 in this way the vibrations of the building, as calculated from observations with apparatus No. 1, were checked exactly.

Incidentally, it was found that a swaying motion of 0.002 in., with a frequency of 96 vibrations to the minute, could be plainly felt, and that 0.006 in. gave a decided sensation of dizziness to an experienced bridge climber.

The purpose of these experiments, namely, to obtain definite facts bearing upon the safety of the building, was very satisfactorily served by this apparatus. These facts refuted the statements of those who accepted the testimony of human sense and exaggerated it, and they enabled the engineer to give an opinion, supported by figures, to show that, in the present circumstances, the owner has nothing to fear for the safety of his building.

## A 3-MILE CAUSEWAY.

A 17,000-ft. causeway is proposed for connecting the city of Miami, Fla., and the town of Miami Beach by spanning Biscayne Bay. An election to vote on a bond issue for the carrying out of this improvement was held on Aug. 22.

The causeway will consist of approximately 12,800 ft. of solid fill and 4,500 ft. of concrete pile trestle construction with two moveable bridges of the bascule type. The causeway portion consists of solid sand fill, with stone rip-rap protection for the side slopes and provides for a 6-ft. concrete side walk, two curbs and gutters, a 40-ft. roadway of oiled macadam and an electric railway track, together with suitable parking space on each side of the roadway. It has an over all width of 105 ft. on top.

The viaduct portion will be of concrete pile trestle construction with reinforced concrete caps, stringers, floorslab, and with permanent pavement in the highway portion. It will have stringers in the area occupied by the electric railway track. This portion provides for a sidewalk 6 ft. wide, two curbs and gutters, a 20-ft. roadway and an electric railway track. Klyce & Kackley, Real Estate Bldg., Miami, Fla., are the engineers.

## PERSONALS.

H. P. Kerr has been appointed city engineer of Tillamook, Ore., succeeding Ross Shreve, who resigned recently.

G. N. Wood, formerly assistant city engineer of Douglas, Ariz., and more recently city engineer of Chanute, Kan., has been appointed city engineer of Douglas, Ariz.

Legare Keith has been appointed city engineer of Columbia, S. C., succeeding John McNeal, who resigned recently. F. C. Wyse, formerly superintendent of water works, was elected assistant city engineer.

George H. Blakeley, who was recently elected president of the Bethlehem Steel Bridge So., a subsidiary company of the Bethlehem Steel Co., is a graduate of Rutgers' College, class of 1884. He was engineer of the Riverside Bridge Co., Paterson, N. J., from 1887 to 1888, and assistant engineer, Erie Railroad, 1888 to 1890, in charge of bridge construction. In 1890 he became chief engineer, Passaic Rolling Mill Co., Paterson, N. J., at that time well known builders of bridges, and continued in this position until 1905. From 1902 to 1905 he was also constructing engineer for the Passaic company as well as structural engineer. In 1908 Mr. Blakeley became manager of structural steel sales of the Bethlehem Steel Co. He is a director of the company, in charge of its structural steel interests, and which, by the acquisition of Pennsylvania Steel Co., now include the bridge business of the latter. He will retain his present position with the Bethlehem Steel Co. in addition to his connection with the bridge company.

## OBITUARY.

Peter S. Gibson, a veteran land surveyor and civil engineer of Ontario, died Aug. 6, at his home in Willowdale, a suburb of Toronto.

James E. P. Fitzpatrick, superintendent of construction of the government dam on the Mississippi River near Fort Snelling, Minn., died Aug. 6 from injuries sustained when an automobile which he was driving turned turtle and went over an embankment.

A. B. Stickney, formerly president of the Chicago, Great Western Railway, died August 9, at his home in St. Paul, Minn., after an illness of one week. Mr. Stickney was born at Wilton, Me., in 1840 and entered railway service in 1871. He was connected first with the St. Paul, Stillwater & Taylor's Falls Railway, serving as vice-president and general manager, attorney, etc. He later was superintendent of construction for the St. Paul, Minneapolis & Manitoba Railway; from 1880 to 1881 he was general superintendent of Canadian Pacific Railway; from 1881 to 1882 he was vice-president of the Minneapolis & St. Louis Railway. He also about this time built the Minnesota Central Railway. In 1884 he became president of the Minnesota & Northwestern Railway and continued in this position until consolidation with the Chicago, St. Paul & Kansas City Railway, when he became president of the latter road, holding that office until 1890. From this year until 1892 he was chairman of the board of directors, and from 1892 to January, 1908, chairman of the board of directors of the reorganized company of the Chicago, Great Western Railway. From 1894 to 1900 he was president of this road and from January, 1908, to 1909 receiver.

## NEW CATALOGS.

**Paints.**—Paper; 5 in. x 8 in.; 32 pp. Toch Bros., New York.

This book is intended for architects, engineers, contractors and the men who pay the bills. It describes the uses of the various "R. I. W." preservative paints and compounds manufactured by Toch Bros. Methods of application are given, as well as specifications.

**Overhead Carrying Devices.**—Paper; 6 in. x 9 in.; 48 pp. New Jersey Foundry & Machine Co., New York.

Catalogue 88, issued recently by this company, describes and illustrates the various lines of hand and electric cranes, monorails, trolleys, hoists, etc. Ten pages of the catalogue are given up to illustrations showing interesting installations. Numerous tables of capacities, speeds, safe loads, etc., are given.

**Pumps.**—Paper; 6 in. x 9 in.; 8 pp. The Pelton Water Wheel Co., San Francisco, Cal.

This is Bulletin No 9. It illustrates and describes the Doble centrifugal pump. This pump has many interesting features, the most notable perhaps being the line diffusion system of the volute.

**Concrete Mixers.**—Paper; 8 in. x 11 in.; 24 pp. Ideal Concrete Machinery Co., Cincinnati, O.

Describes and illustrates the 5, 7, 10 and 14-ft. capacity batch mixers manufactured by this company. Specifications and prices are given. One important feature of these mixers is their flexibly hung roller bearings, which prevent binding that might result from springing or twisting of the mixer frame due to uneven ground.

**Expanded Metal.**—Paper; 6 in. x 8 in.; 16 pp. Northwestern Expanded Metal Co., Chicago. Ill.

This is the July number of Expanded Metal Construction, a monthly publication of this company. The first ten pages of the issue are devoted to a description of small stucco houses. Numerous illustrations of this type of construction are given.

**Condensing Plants, Drill Sharpeners, Compressors.**—Paper; 6 in. x 9 in. Ingersoll-Rand Co., 11 Broadway, New York.

The Ingersoll-Rand Co. has issued recently three new bulletins, as follows:

Form 9024—32 pp., 6x9, on Steam Condensing Plants—Beyer Barometric Type. This catalog describes the fundamental principles of steam condensing plants in minute detail and makes comparisons of the Beyer barometric condenser as against low level jet condensers and surface condensers. All auxiliary apparatus, such as vacuum pumps and centrifugal water pumps are illustrated and described in detail.

Form 4122—24 pp., 6x9, describes the I.R. Model Leyner drill sharpener. To those interested in properly formed and sharpened bits this bulletin will be of timely interest, as it explains and illustrates the sharpener in detail and shows the various styles of bits.

Form 3033—28 pp., 6x9, describes the Imperial "XPV" Duplex steam driven compressors produced to meet a universal demand for a steam-driven air compressor designed and constructed to operate satisfactorily under "high pressures" and "superheat" as well as under "ordinary steam" conditions. Catalog shows the various sizes and capacities and explains in detail the operation of the "Imperial" piston valve.

Surveying, Drafting and Office Issue
of

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., AUGUST 30, 1916. Number 9.

## ANNOUNCEMENT OF THE SURVEYING AND DRAFTING QUARTERLY ISSUES OF ENGINEERING AND CONTRACTING.

When it is remembered that almost every civil engineer is interested in surveying or drafting, either as a manipulator of instruments himself or as a director of other engineers who measure, stake out or draft engineering works, it is rather remarkable that there has been no periodical like the one of which this issue is a forerunner.

We think that we have at last found a solution of the problem that will meet the approval both of ,subscribers and of advertisers. In brief it is this: Four times a year, in the months having five Wednesdays, the articles in the fifth issue of Engineering and Contracting will be devoted to surveying, drafting and engineering office management. There will be the regular construction news items in this fifth issue as every one of the 52 issues of year. Hence it follows that our contractor readers will find this fifth issue as essential as any other, because of its news, and many of them will gain valuable information from its articles on the measuring and staking out excavation, blue printing, drafting, etc.

The articles in this Surveying and Drafting Quarterly will appeal to nearly every civil engineer, and the appeal, we believe, will be stronger because the articles are bunched in four issues than has been the case when they were scattered through 52 issues of the year.

Each of thtse pages of articles in this issue would fill more than four pages of text book size, so that the four issues during a year will give the reader the equivalent of a 400-page book on surveying, drafting and engineering office system. There will be a few readers, perhaps, who will subscribe only for this quarterly, and pay for it at 25 ct. a year. But the vast majority will take this quarterly either as part of a yearly subscription for the 52 issues at $3, or in combination with one or more of the one dollar monthly issues, the names of which appear on the front cover.

Surveying and drafting are basic subjects in every college course in civil engineering, and rightly so, for probably more than half the graduates of civil engineering colleges spend their first years as surveyors or draftsmen. A very large percentage of all civil engineers spend a portion of their time every year in surveying and drafting. There is, then, no lack of interest in this branch of engineering practice. Are there enough changes and improvements in the art to warrant publishing the equivalent of a 400-page book yearly? We are satisfied that there are. But even if there were not, it is a fact that a vast amount of excellent information previously published is virtually beyond the reach of most engineers, since it lies catacombed in the transactions of engineering societies. We purpose reprinting the best papers that have appeared in past years, and thus bringing them within the reach of all engineers. This alone would make the Surveying and Drafting Quarterly of great value to every civil engineer, but we shall not confine our effort to presenting material that is old in point of original publication, though new to the eyes of most of our subscribers. We plan to secure contributed articles as to the latest developments in the measurement, and calculation of quantities, in the staking out of work, and in sketching, photographing and drafting structures. Added to this we shall give collateral development of new systems of engineering office system and management.

Even to enumerate these features that this Surveying and Drafting Quarterly will cover, should suffice to indicate that it will mark a new departure in civil engineering journalism.

## ILLY REWARDED GOVERNMENT BUREAUS.

Few bureaus of the Federal service are more penuriously treated than those devoted to topographic mapping, triangulation and precise leveling of our territory. Many of these bureaus are working with an appropriation that a forehanded Congressman would feel downcast in securing for a prairie town post office. And yet there are few Federal bureaus that are performing a more fruitful labor. Sometimes one wonders whether engineers realize how much work of direct utility to them is being done in precise leveling and triangulation by the Coast and Geoditic Survey. Do they realize that a vast volume of this painstaking recording of fundamental geographic positions and elevations is going on in the interior states? We sincerely trust that such is the case. And the topographic mapping of the Geological Survey is another service for engineers of even more immediate utility. Rarely, however, in recounting their work do engineers pay tribute by acknowledgment to such aid as they may obtain from these surveys. This is not want of appreciation; it is merely the human habit of ignoring customary service. Provision of exact topographic maps by the Geological Survey of the country through which the engineer's railway or line of aqueduct is to run is accepted by the engineer without thought of remark much as the average city dweller accepts the customary flow of water from his bathroom tap without mental stir. It is in the same habit of mind that the engineer comes to act as if these bureaus functioned without advantitious aid. No one knows so well as the engineer that precise detailed surveying costs money. No one can importune Congress with such force as can the engineer for adequate financial support of these bureaus. If the engineer doubts that their financial support is not adequate let him read the latest annual reports of either of the bureaus which have been named.

We remarked above that engineers are too often careless in citing the aid received by them from the Geological Survey topographical maps. As an example of the opposite course we quote from the record of the Catskill Aqueduct prepared by Mr. Lazarus White:

> The first location studies were made on the United States Geological maps. These maps, drawn to a scale of about a mile to an inch with 20-ft. contours, are accurate enough for general locations, and have the great advantage over larger maps that they give a birdseye view of the whole country, enabling the plotting of alternate locations and the computation of their relative costs. Were it not for these maps, great stretches of the country would have had to be surveyed, broadcast, before any definite idea as to the best place to put the aqueduct could have been obtained. This would have meant eithr many years more of work on the preliminary locations with a great expenditure for surveys, or, more likely, due to the limited time, the selection of a route much more costly to construct than the one adopted. This is shown by the Hudson crossing. After considerable work had been done on the location of a crossing at New Hamburg an extended study of the country west of the Hudson, as shown on the geological maps, revealed the possibility of an entirely different route with 16½ miles of inexpensive cut-and-cover as opposed to much more costly work on both sides of the river at New Hamburg, and showed that a much better crossing could be obtained in the neighborhood of Storm King, at an estimated saving of about $2,000,000. It was found

> that nothing paid as well as plotting on the geological maps as many possible locations as could be conceived, making rough comparisons of their relative costs. From these many locations a few of the most favorable lines were selected to be thoroughly studied on the ground.

Another reason for this quotation lies in the fact that it presents an example of special saving in the cost of engineering work through the aid received by one of our Federal survey services. These Surveys are in need of greater appropriations to extend their work and engineers personally and through their organized associations should exert influence toward securing these appropriations.

## FORTY-FIVE THOUSAND DRAFTSMEN AND DESIGNERS AND FIFTY-TWO THOUSAND CIVIL ENGINEERS AND SURVEYORS IN 1910.

In our issue of Aug. 16 we gave the number of engineers of different classes in America in 1910, and the number of engineering students. It is interesting to note that in addition to the 52,033 "civil engineers and surveyors," there were 33,314 draftsmen, 11,788 designers and 2,347 inventors, according to the U. S. Census for 1910. The census for 1900 gave 20,153 civil engineers, 6,034 surveyors and 18,956 "draftsmen, designers and inventors," from which we see that the numbers of each class had more than doubled in ten years.

If the same rate of increase has occurred during the last six years, there are now fully 70,000 draftsmen and designers in America. What percentage of these are engaged in civil engineering work is not known, but the percentage doubtless exceeds 30 and is probably nearer 40.

The 1910 census does not segregate surveyors from civil engineers, as does the 1900 census. Since the 1900 census shows that about 23 per cent of these two classes were surveyors, it may be inferred that fully 12,000 of the 52,033 in 1910 were surveyors. The number of surveyors in 1916 probably falls not far short of 20,000. So, if there are 28,000 civil engineering draftsmen and designers and 20,000 surveyors, the present total of these two is about 48,000.

If in 1910 there were 40,000 civil engineers, in addition to 12,000 surveyors, and if the number be increased at as rapid a rate during the past six years as during the previous ten years, there are now approximately 60,000 civil engineers. Summing up, then, there now are more than 100,000 civil engineers, surveyors and civil engineering draftsmen in America.

How many contractors for civil engineering construction there are is not known. In 1910 the census gave 174,422 'builders and building contractors." Probably 25 per cent of these were contractors for works designed by civil engineers, or, say, 40,000 engineering contractors. The number in 1916 would therefore exceed 50,000.

The three leading civil engineering and contracting papers have a combined circulation not much in excess of 50,000, from which it may be inferred that not one in three of the total number of civil engineers, surveyors, civil engineering draftsmen and designers and engineering contractors subscribes for any one of these three leading papers.

The American Society of Civil Engineers has a membership of about 8,000, or less than one-sixth the combined subscription list of the three leading civil engineering papers. This interesting fact gives some conception of the possibility of further growth in the membership of this great society. It also indicates, we believe, a very large field for the development of other societies of a civil engineering nature, such, for example, as a society of structural engineers.

## "I AM TOO BUSY TO READ."

How many busy men find excuse for their failure to read engineering papers by saying that they are too busy to read? How many of these ultra-busy people have ever calculated the length of time it takes to read every word in the bulkiest issue of an engineering periodical? There is, we believe, more of ignorance than of laziness in the excuse: "I am too busy to read engineering papers."

Time yourself and you will find that, reading deliberately, you will go through one of these large pages in five minutes. You can, therefore, readily read 24 pages of these articles in two hours. If, then, you were to schedule 20 minutes a day for the reading of Engineering and Contracting you could read every article that we publish during the year, and in doing so, you would miss little of consequence relating to progress in the civil engineering world.

It is a curious fact, and one upon which comment is seldom heard, that young men freshly graduated from engineering colleges so frequently give up all serious, methodical study of engineering. We have seen evidence often that this is so, and so often as we have seen it there has risen a question whether engineering colleges are defective in their methods of training students or whether human nature, through innate perversity, rebels at daily study, however short the study period may be and however great its ultimate fruitage.

At times we have wondered whether civil engineers in general take the gloomy view that their incomes will not increase with increase in their personal efficiency. There is many an engineer, it is sadly true, who matures in knowledge and skill as he matures in years without securing an increase in income at all proportionate to his increased efficiency. Yet these are often the very men who prove the rule by being exceptions to it; they are apt to be the continuous students.

Without at this time reviewing all our reasons for the opinion we hold, we may say that we believe that few engineering colleges grind into a young man's mental fibre enough of the salt of real knowledge. They fail to develop the habit of perpetual search for greater efficiency. The average boy enters his engineering course with an undue reverence for ability to pass "exams," and he is fortunate indeed if he finishes his course with less respect for that ability and a far greater regard for aptitude at and inclination for the search for usable facts.

It has become the fashion of late years to say that the primary object of an engineering course is to teach students how to reason. Yet, taking them at their word, how many engineering teachers prescribe courses in logic, the science of reasoning? Important as it is to teach the principles of correct reasoning, there is something of greater importance in the training of men. We refer to the formation of habits. Among all the helpful habits none exceeds in value the habit of search and research—of investigation of nature at first hand and of investigating the investigations that others have made. It is this latter habit that we are now discussing, the habit of reading and studying the usable facts that other men have recorded in the technical press.

But when this sort of study is urged upon the busy engineer—and what one among us does not think himself busy?—the common excuse is: "I am too busy to read." Are you? Seriously ask yourself: Am I? If you are, then you have cut off almost every road to further knowledge and power save such narrow pathways as you may laboriously hack for yourself, unaided, through the jungle of ignorance.

## THE DISAPPEARANCE OF "SURVEYORS" FROM STATE SOCIETIES OF ENGINEERS AND SURVEYORS.

One of the most serviceable classes of associations of engineers is the State Society. Illinois, Michigan, Ohio, Connecticut, Idaho and a score of other states' societies of men engaged in engineering work have long records of very remarkable work to their credit. Twenty or twenty-five years ago large numbers of the members of these societies were surveyors. The word "surveyors" was a part of the name of many state societies. In recent years this word has been dropped from the society name in a number of instances. Where it is still retained it possesses only nominal importance. The work and interests of the "surveyor" have been subordinated to that of the "engineer" in all of our state societies. It is perhaps logical and proper that this should be so. The surveyor members were land surveyors and land surveying in most of our more developed states has ceased to be of the prominence that it once was. The greater part of the surveying required nowadays is in connection with engineering construction and is an incidental part of such construction. In the total of the engineering work the item of surveying rarely is important enough to be given detailed analysis and discussion.

Despite all the logic of its reason one who knew the older days when surveyors played a leading role in state society meetings and discussions must in a measure regret their disappearance. They were men of special skill. They were the pioneers of engineering. Their work was performed under the stern conditions of unpopulated country. They were rugged in body and character. They came to the annual meetings of their state society with a fresh enthusiasm that was almost inspiring to the jaded engineer member from town and city. They were good men and they have gone, but surveying is yet the pioneer task of all civil engineering and it should have attention in the work of the societies which in many instances owe their being to the land surveyors of a generation now nearly passed.

The secretaries of our state societies have always a puzzling task to secure novelty in the society's annual program of papers and discussions. Let them for the coming winter's conventions devote a large share of this program to papers and discussions on surveying. This subject has been so long neglected that it would seem almost new to the members. It is a subject which every member can discuss. It is a subject, a knowledge of which must precede all engineering design and construction.

## HOW A "MERE SURVEYOR" MAY IMPRESS THE PUBLIC.

Gradually it is dawning upon engineers that if they would gain greater respect for their scientific knowledge they must use "publicity methods" to acquaint people in general with what the term engineer really signifies. That a civil engineer is a surveyor most men know, but how much more than a surveyor he may be is less well understood. Yet to be "merely a surveyor" is not so mean an accomplishment as many of our "highbrow" engineers imply when they mate the word "merely" to the word "surveyor."

Perhaps the majority of civil engineers begin their careers either as "mere surveyors" or as draftsmen. And if the truth were told, even the most eminent and highly remunerated experts in the civil engineering profession would admit that their early years of surveying called for as much initiative and hard work as their later years of "experting." Also they would acknowledge having experienced quite as keen a thrill of satisfaction at having seen the headings of a tunnel meet as at having finished the design of a great bridge.

The surveyor comes more often in contact with the public than does the designer of engineering structures, and he has a better opportunity, therefore, to impress directly upon the public mind what it means to be an engineer. The writer recalls an incident that serves to illustrate how respect for engineering knowledge may be instilled into "practical men" who often entertain an only half-concealed contempt for engineering theory.

A survey for road improvement was being made under the writer's direction, under the "road viewers'" direction. The "road viewers" were three farmers whose official capacity gave them power to select an engineer and to locate and build roads in their "road district." The writer, fresh from an engineering college and doubtless very verdent in the eyes of the old "road viewers," had been hired to be the instrumental "Poobah" and lord high manipulator of the pencil and reckoning sticks. As for the rest, the "road viewers" were that. They knew exactly where the road should be relocated, where it should remain as it was, what it should be surfaced with, and how it should be drained—for they were very "practical men."

The writer deemed it wise not to contest their plans and ideas until he could somewhat overwhelm them with evidence of their lack of technical knowledge. He ran a stadia traverse survey along the old road, taking elevations of all abrupt changes in profile slope, and running a few hand-level cross-sections at intervals into the woods on each side of the road. The use of the stadia itself proved to be the first means of arousing a little respect for the surveyor's art, for to measure distances by squinting through a telescope at a rod was new to the "road viewers." Purposely the writer did not explain to them how simple the stadia process is, for his primary object was to gain from his employers respect for engineering as a science. The speed of the work and the smallness of the gang pleased the "viewers" not a little, for the $5 per diem that the engineer was getting seemed to them a veritable hold-up, particularly so in view of the verdancy of the highwayman.

Five miles of traverse were run in a day, calculations and plot made that night, and a cutoff survey line started at 7 a. m. next morning through the woods. Those were Washington woods, and whoever has surveyod along Puget Sound needs be told no more. It meant strenuous work to cut a line half a mile a day. The "road viewers" being skilled axmen, and anxious to earn their per diem also, sweated at the task and at noon held a convention at which it was duly moved, seconded and unanimously carried that the new road should not go where the engineer was locating it. The engineer assured them that he was not sure but that they were right. He couldn't tell until he had finished that line, which was to be half a mile long and would come out of the woods at the creek where the bridge was.

"So, you don't know yourself what you are running this line for?"

"I didn't say that. I mean that it is a trial location and may have to be changed."

"Well, that being so, we have decided to save half a day of your time and change it now. We are going to have the new road follow the old road."

"If you do that before I have finished this line, my friends, you'll have to hire a new engineer. If there is anything that I know at all, it is how and where to locate a road. Why did you hire me if you know more than I do about surveying?"

"That's where you are wrong, engineer. We know where to put the road. What we hired you for is to measure it out and figure the cost."

"And that is exactly what I am doing, for the cost depends on where the road is located. This line that I am running will save a quarter of a mile of distance and will eliminate the climb over a high hill. Go back and see how level the ground is for the last quarter of a mile."

Just then a train passed and the screech of its whistle made it seem nearer than it was. One of the "viewers" remarked sotto voce that he'd bet the line we were surveying would cross the railroad track before it reached the old road.

"If you really think so and like to bet, I will wager you that this line I am running will strike within 2 ft. of the peg we drove yesterday in the road at the creek."

The "viewer" was game, so we bet the beers for the crowd on the outcome of the line. Late in the afternoon we broke through the woods into the road clearing at the creek. The writer, standing on a great fallen tree on which his transit was mounted, could see through his telescope the guard stake one foot to the left of the "hub" that he had wagered to strike within 2 ft. The rodman raised his "flag" and the writer began to wave him into line. As a fact the vertical hair cut a point about a foot away from the "hub," but, as the position of the "hub" was known to the writer because he could see the guard stake, he decided to do some "really fine work." Accordingly, he waved the reluctant rodman —who was the "viewer" who had bet the beer—back and forth until the "hub" was almost exactly on line between the rod and the transit. Then the O.K. wave with both arms akimbo was given. Instantly a shout of laughter went up.

"The beers are on you, Jim. Guess you'll not bet against an engineer's own game again."

To some engineers it may seem strange that so simple an event could have had any far reaching effect. But the story of the engineer's "wonderful precision" went abroad, and it not only led him to get a great many jobs in that county, but it served effectively to give a greater confidence in what an engineer can do. Particularly were the three "road viewers" impressed when a few weeks later the new cutoff road was cleared and graded, for they could then see for themselves its superiority over the old roadway.

Twenty odd years later the writer rode in an automobile over that road and called on the only one of the three old "road viewers" still living. He said:

"Many's the time I have told how Jim lost the beers on his bet with you. I guess everyone hereabouts has heard of it. What's more, they all say that there's no better road in the county today than the one you and we laid out—gad, it's so long ago I want to ferget the years."

## WHO INVENTED BLUEPRINTING?

Would not the teaching of every engineering subject be more effective if biography were made part of the technical text? To learn that Sir John Herschel, for example, invented blueprinting in 1840 arouses interest in that process of sun printing. That an astronomer should study chemistry and invent a method of photographing on paper, and that this method should be used to this day, the world over, by engineers, is a fact of the sort that arrests an engineering student's attention. Half the battle is won by the teacher who can interest his students. What means of arousing interest is so certain in its efficacy as telling about the origin and the originators of tools and processes? Let us have more of the authorship methods of Samuel Smiles, whose "Self Help," "Lives of the Engineers" and other works teem with human interest.

## EDITORIAL PARAGRAPHS.

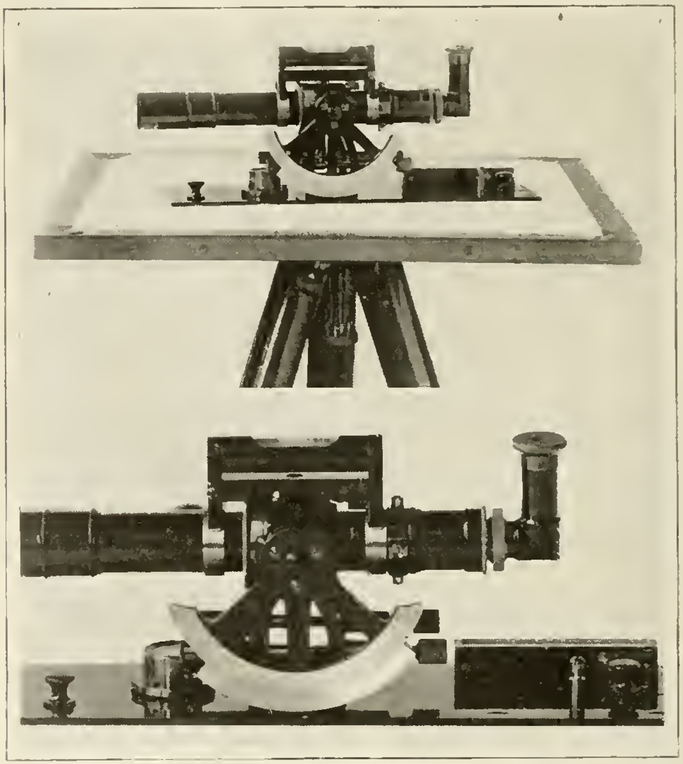
That the census for 1910 shows a total of 45,000 "draftsmen and designers" will surprise many engineers, but it will surprise few draftsmen who were forced to look for positions two years ago when the war caused so many engineering firms to reduce their staff. To a man seeking a drafting position then it often seemed that the remaining 44,999 of his clan were after the same job.

The first summer school of surveying was the one started by Prof. Henry S. Munroe, of Columbia University. Our recollection is that the summer course was made part of the regular engineering courses of Columbia about 40 years ago. Many other engineering colleges have adopted Prof. Munroe's plan of giving students training in surveying during the summer months that would otherwise be given up to vacation.

Had there been a draftsman's union it doubtless would have opposed the introduction of the blueprint process. Today a blueprint is almost symbolic of drafting. The very fact that many replicas of an original drawing can be speedily and cheaply made accounts, in large measure, for the large number of those who earn a livelihood by wielding a right-line pen.

## THE GURLEY EXPLORERS ALIDADE.

The plain table alidade has "evoluted" within a period remembered by not very old surveyors from a blade with two slotted sight standards to a telescopic alidade not much less a precise and complex mechanism than a theodolite. The illustrations show one of the latest and most finished of these recent plane table alidades. At first glance its only pronouncedly novel feature is the elbow eye piece, and this is its chief novelty. One of the most fatiguing tasks in plane table surveying is that of frequently craning the neck to obtain horizontal sights through the alidade telescope. The elbow eye piece obviates this awkward sighting position and increases speed and decreases labor to a noticeable degree. As the instrument stands pictured it has a graduated blade, a Beaman stadia arc, a circular level and a trough compass besides the usual striding level and other fittings. As an instrument for oil and gas land prospectors, geologists and topographic surveying generally it is a notably complete instrument. While the elbow eye piece is the novelty, the characteristic feature is the Beaman stadia arc. The makers are W. & L. E. Gurley, Troy, N. Y.



Plane Table Alidale with Elbow Eye Piece and Beaman Stadia Arc.

## A SIMPLE METHOD OF SECURING APPROXIMATE HORIZONTAL DISTANCES.

A method of approximating horizontal distances is described by G. F. Schlesinger as follows:

The method, in brief, consists of turning off a horizontal angle of 1° 9′ with the transit, and then measuring the distance between the first and last pointings at the extremity of the course whose length is to be determined. This distance in hundredths of a foot, divided by 2, will be the actual distance in feet; depending, of course, on the fact that the sine (or tangent) of 1° 9′ is 0.02 (approximately).

The angle of 34′ may be used, in which case the division by 2 is not necessary and the "spread" is one-half; but the approximation will be greater. The error due to the approximation using the angle 1° 9′ is 1 in 290, and, even in view of other inaccuracies, the results will be sufficiently close for certain classes of work.

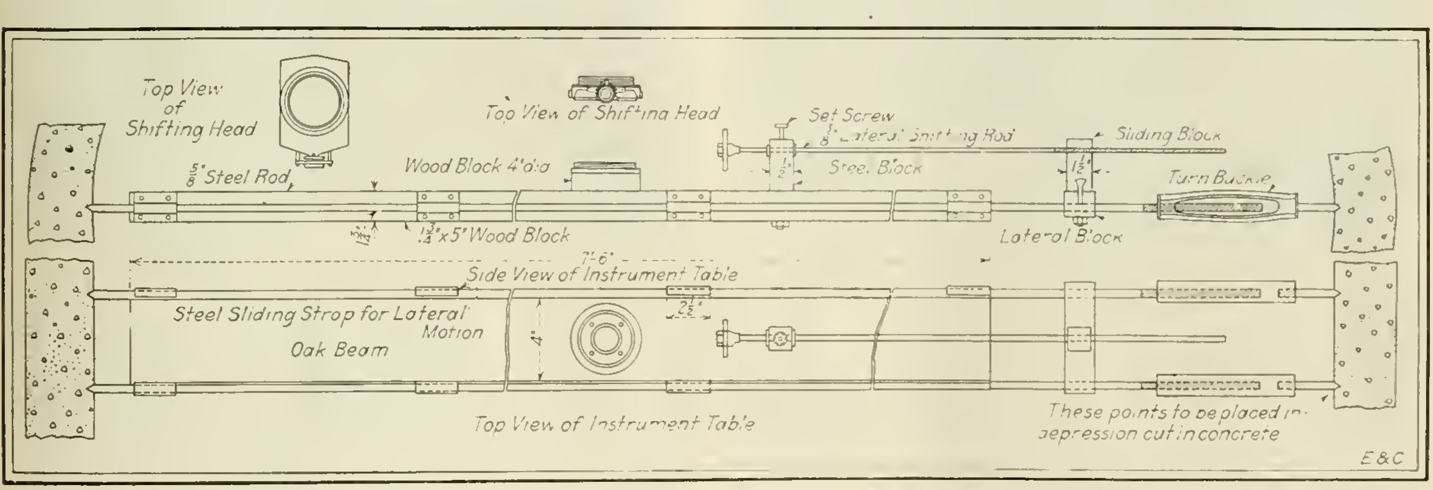
By means of this method, remarkable progress can be made in determining small drainage areas by running an angle line around the divide; or, in some cases, by "side shots" from some central point or points within the area.

The party is composed of two men equipped with a plain transit, sight rod, metallic tape and ordinary chaining pin. The rodman selects the points ahead and the transitman takes the magnetic bearings of the courses (when practicable), then sets off the horizontal angle for lining in the rodman for the second pointing. The rodman, having inserted the pin, holding the ring at the end of the tape, at the first point, measures the distance to the second. After marking the first point so that it may be readily found by the transitman, he then proceeds to the selection of the next station, while the transitman moves up.

The following points can be made for this means of approximating horizontal distances: It permits the use of the plain transit reading to minutes with the ordinary cross wires, requires no stadia or level rod, no reduction to the horizontal, and longer courses can be taken than by the stadia or gradienter method. The transitman is not limited by the distance at which he can distinguish figures on a rod, but by the distance at which he can clearly see a sight rod.

## AN INSTRUMENT TABLE FOR TUNNEL SURVEYING, MILWAUKEE CITY ENGINEER'S DEPARTMENT.

An instrument table which permits line and grade to be given without interference with mucking operations has been developed by the City Engineer's Office of Milwaukee, Wis., and is illustrated by the accompanying drawings. The shore tunnel of the Linwood Ave. intake in which this device is being used has a concrete lining which is kept completed close to the excavation, and the spoil track is carried on a timber platform spanning the hollow of the invert of this lining. This timber track platform is not a stable base on which to set instruments; moreover, instruments set on this platform interfere with the spoil cars. By means of the instrument table illustrated a stable and easily adjustable mounting is had for either transit or level and one which spans the tunnel high enough up to permit spoil cars to pass underneath.


Top View of Shifting Head
Top View of Shifting Head
Set Screw
3/8" Lateral Shifting Rod
Sliding Block
5/8" Steel Rod
Wood Block 4" dia
Steel Block
1 1/2"
1 1/2"
Turn Buckle
1 3/4"x5" Wood Block
Lateral Block
7'-6"
Side View of Instrument Table
Steel Sliding Strap for Lateral Motion
2 1/2"
4"
Oak Beam
Top View of Instrument Table
These points to be placed in depression cut in concrete
E&C

Tunnel Instrument Table, Linwood Avenue Tunnel, Milwaukee, Wis.

The main structural features and dimensions and the method of mounting the table are shown by the drawings. It will be noticed that the oak beam or table proper slides between two parallel rods whose ends set into the tunnel sides. On this board is fastened a standard screw head such as surmounts the regulation tripod. Attached to the board and passing through a fixed cross-head on the bars is an adjusting screw or lateral shifting rod, by which the board and therefore the instrument can be minutely adjusted laterally of the tunnel. On the tripod head is screwed a Berger cross-slide head by which the instrument can be shifted longitudinally of the tunnel sufficiently to obtain accurate centering under a plumb bob suspended from the roof plugs.

Information from which this description has been prepared was furnished by Mr. L. G. Warren, Resident Engineer, Linwood Avenue Intake System, Milwaukee, Wis. Mr. Geo. F. Staal is city engineer of Milwaukee.

## METHODS AND COST OF MAKING A SNOW SURVEY FOR IRRIGATION SYSTEM.

Contributed by F. T. Cummings, Engineer, Rock Creek Conservation Co., Rock River, Wyo.

A survey to determine the amount of snow and its moisture content, lying on the Sand Lake Drainage Area, was made on May 5 and 6, 1916, by the Engineering Department of the Rock Creek Conservation Co. This company, of which Frank C. Bosler of Carlisle, Pa., is President, is engaged in the irrigation of some 80,000 acres of land in the vicinity of Rock River, Wyo.

The area surveyed is that which is drained by Sand Lake, one of the numerous lakes lying at the foot of the Snowy Range of the Rocky Mountains. Sand Lake is the site of one of the reservoirs comprising a part of the company's system. The survey was made in co-operation with the local office of the U. S. Weather Bureau at Cheyenne, Wyo.

**Description of Data.**—The map, which is on a scale of 1 in. = 1,000 ft., is an enlargement from the general map of the Medicine Bow National Forest, published by the U. S. Forest Service. The enlargement was made by the method of similar squares. The topography, area covered by timber, parks, etc., and the location of the streams, are taken from this map. The boundary of the drainage area and that of the lake and of the high water line of the proposed reservoir are from surveys made by the engineers of the company. The points at which snow measurements were taken were located by transit and stadia during the summer of 1915. These points are marked by small signboards on which is painted the number of the point and which are nailed to nearby trees.

Table I gives the data taken in the field at each point and also shows the general slope of the country in the vicinity of each point and the distribution of the different readings according to slopes.

Table II shows the distribution of the data according to contours of 100 ft. interval and according to area covered by timber, parks, etc.

Table III gives a summary of the daily snowfall for the season. During September some snow fell, but as it did not remain on the ground it has no relation with the data obtained from the snow survey. The data given in the table is that obtained by the observer of the co-operative weather bureau which is maintained by the company in conjunction with the U. S. Department of Agriculture. Three of these stations are maintained by the company, one at Rock River, one at Arlington, about 18 miles southwest, and the third at Sand Lake, about 35 miles southwest of Rock River. At these stations the daily maximum and minimum thermometer readings are recorded and also the daily precipitation is measured by the standard rain gage and tube, the instruments being furnished by the Government.

TAPLE I.—SAND LAKE SNOW SURVEY. SNOW READINGS.

| Point No. | Depth of snow, in. | Moist., in. | % moist. | Slope facing. |
|---|---|---|---|---|
| 1 | 66 | 23.2 | 35 | South. |
| 2 | 57 | 20.9 | 37 | South. |
| 3 | 60 | 25.7 | 43 | Southeast. |
| 4 | 70 | 26.2 | 37 | East. |
| 5 | 33 | 12.5 | 38 | East. |
| 6 | 56 | 20.0 | 36 | East. |
| 7 | 23 | 8.5 | 37 | East. |
| 8 | 77 | 22.9 | 30 | South. |
| 9 | 43 | 14.9 | 35 | Southeast. |
| 10 | 0 | 0.0 | 0 | East (on Windy Hill). |
| 11 | 75 | 28.8 | 38 | North. |
| 12 | 71 | 26.3 | 37 | Northwest. |
| 13 | 34 | 13.9 | 41 | Northeast. |
| 14 | 26 | 13.4 | 52 | Northeast. |
| 15 | 56 | 23.2 | 41 | Northeast. |
| 16 | 47 | 18.8 | 40 | Northeast. |
| 17 | 79 | 25.4 | 32 | Northwest. |
| 19 | 71 | 24.7 | 35 | Northwest. |
| 20 | 73 | 23.9 | 33 | Northwest. |
| 21 | 75 | 26.8 | 36 | Northwest. |
| 23 | 42 | 14.7 | 35 | North. |
| 24 | 31 | 9.6 | 31 | North. |
| 40 | 56 | 21.8 | 39 | South. |
| 41 | 77 | 28.2 | 37 | South. |
| 42 | 48 | 22.7 | 47 | Southeast. |
| 43 | 48 | 21.6 | 45 | Southeast. |
| 44 | 61 | 25.8 | 42 | East. |
| 45 | 27 | 14.2 | 53 | East. |
| 45A | 43 | 25.4 | 35 | Southeast. |
| 46 | 29 | 13.0 | 45 | Northeast. |
| 47 | 55 | 22.0 | 40 | North. |
| 48 | 40 | 11.5 | 29 | Northwest. |
| 49 | 76 | 20.9 | 28 | Northwest. |
| 50 | 66 | 21.6 | 33 | Northwest. |
| 51 | 84 | 28.1 | 33 | Northwest. |
| 52 | 33 | 13.0 | 39 | Level. |
| 53 | 41 | 16.0 | 39 | Level. |
| 54 | 58 | 24.0 | 41 | Level. |
| 55 | 48 | 19.2 | 40 | Level. |
| 56 | 59 | 30.1 | 51 | Level. |
| 57 | 34 | 14.6 | 47 | North. |
| 58 | 66 | 20.1 | 30 | North. |
| 59 | 71 | 23.8 | 34 | North. |
| 60 | 76 | 29.2 | 38 | North. |
| 61 | 39 | 14.5 | 37 | North. |
| 62 | 43 | 18.4 | 43 | Southeast. |
| 63 | 38 | 13.0 | 34 | Northwest. |
| 63A | 83 | 22.4 | 27 | Northwest. |
| 64 | 29 | 13.0 | 45 | Southeast. |
| 65 | 33 | 11.7 | 36 | Northeast. |
| 66 | 43 | 18.0 | 42 | Level. |
| 70 | 91 | 30.4 | 33 | Northwest. |
| 71 | 48 | 30.2 | 41 | Northwest. |
| 72 | 23 | 9.5 | 63 | North. |
| 73 | 39 | 11.6 | 30 | North. |
| 74 | 74 | 25.4 | 34 | Northwest. |
| 75 | 48 | 19.5 | 41 | Northwest. |
| 76 | 71 | 22.5 | 32 | Northeast. |
| 77 | 63 | 27.4 | 43 | East. |
| 78 | 59 | 22.9 | 39 | East. |
| 79 | 61 | 23.3 | 38 | East. |
| 80 | 42 | 18.4 | 44 | North. |
| 81 | 39 | 12.6 | 32 | East. |
| 81A | 73 | 26.4 | 36 | North. |
| 81B | 30 | 11.2 | 37 | North. |
| .. | 52.8 | 19.9 | 37.7 | Average. |

DISTRIBUTION—SNOW READINGS ACCORDING TO SLOPES.

| Slope. | No. of readings averaged. | Average Depth. | Average Moisture. |
|---|---|---|---|
| North | 16 | 47.4 inches | 17.4 inches |
| Northeast | 5 | 46.8 inches | 18.4 inches |
| East | 11 | 44.7 inches | 17.6 inches |
| Southeast | 7 | 44.9 inches | 20.2 inches |
| South | 5 | 66.6 inches | 23.4 inches |
| Northwest | 12 | 67.8 inches | 23.3 inches |
| Level (lake) | 6 | 47.0 inches | 20.1 inches |

Table IV gives the semi-monthly readings at the Sand Lake snow stake. These stakes are about 2 in. square and 7 ft. high and have an iron point so they can be firmly set in the ground and let remain.

They are marked in inches and are supposed to be so located as to give the average depth of the snow in the vicinity. Six of these stakes are placed within a radius of seven miles of Sand Lake and their readings are taken semi-monthly by the observer stationed at the lake. He notes the depth of the snow as shown by the stake and then determines its moisture content by means of the density tube and scale. The data obtained is sent to the local office of the Weather Bureau at Cheyenne and also to the local office of the Forest Service at Laramie. This data is useful in giving an idea of the amount of snow in comparison with previous years and also of the amount of water to be expected during the following season.

TABLE II.

| Contour. | Total area, in acres. | Area, in acres Timber. | Area, in acres Park. | Area, in acres Burn. | Ac. feet moisture. |
|---|---|---|---|---|---|
| 10120 | 56 | ... | 56 | .. | 87 |
| 10120-200 | 225 | 40 | 177 | 8 | 353 |
| 10200-300 | 238 | 132 | 93 | 13 | 428 |
| 10300-400 | 436 | 196 | 199 | 41 | 761 |
| 10400-500 | 375 | 253 | 111 | 11 | 640 |
| 10500-600 | 323 | 222 | 101 | .. | 537 |
| 10600-700 | 130 | 90 | 40 | .. | 229 |
| 10700-800 | 143 | 45 | 98 | .. | 216 |
| Totals | 1,926 | 978 | 875 | 73 | 3,251 |

TABLE III.—SNOWFALL AT SAND LAKE, OCT., 1915, TO APRIL, 1916 (INCLUSIVE).

| Month. | Snowfall in inches. | Moisture content, in inches. | % moist. | Inches of snow per inch of moisture. |
|---|---|---|---|---|
| Oct., 1915 | 24.50 | 2.99 | 12 | 8 |
| Nov., 1915 | 67.75 | 4.78 | 7 | 14 |
| Dec., 1915 | 44.25 | 3.47 | 8 | 13 |
| Jan., 1916 | 55.00 | 4.07 | 7 | 14 |
| Feb., 1916 | 75.50 | 5.84 | 8 | 13 |
| Mar., 1916 | 34.25 | 2.89 | 8 | 12 |
| April, 1916 | 33.50 | 2.41 | 7 | 14 |
| Totals | 334.75 | 26.45 | .. | .. |

TABLE IV.—SEMI-MONTHLY READINGS AT SAND LAKE SNOW STAKE.

| Date. | Depth of snow, in inches. | Moisture content, in inches. | % moisture. |
|---|---|---|---|
| Nov. 19, 1915 | 19.00 | 3.9 | 21 |
| Dec. 3, 1915 | 30.00 | 6.0 | 20 |
| Dec. 17, 1915 | 34.00 | 6.7 | 20 |
| Jan. 1, 1916 | 45.00 | 10.6 | 24 |
| Jan. 14, 1916 | 59.00 | 12.8 | 22 |
| Jan. 31, 1916 | 57.00 | 13.0 | 23 |
| Feb. 15, 1916 | 70.00 | 16.6 | 24 |
| Feb. 29, 1916 | 73.00 | 18.5 | 23 |
| Mar. 15, 1916 | 76.00 | 17.2 | 23 |
| Mar. 31, 1916 | 80.00 | 21.1 | 26 |
| April 15, 1916 | 75.00 | 23.3 | 31 |
| April 30, 1916 | 66.00 | 24.7 | 37 |
| May 15, 1916 | 48.00 | 19.6 | 40 |

**Computations.**—The areas used in computing Table II were taken from the map by planimeter, five readings of each area being taken and averaged. In selecting the points to be used for the different areas not only those were used which were taken immediately within the area, but others taken near by were used, it being considered that a better average was thus obtained. The points to be used having been assembled, the average is obtained and this quantity is used in computing the acre-feet of moisture contained within the given area. The summary of Table II shows that the total area of the drainage basin is 1,926 acres, from which a total run-off of 3,251 acre feet may be expected. That extreme nicety of calculations are not necessary is shown by computing the run-off from the data given in Table I. From this table the average inches of moisture over the whole area is 19.9, and 19.9 divided by 12 and multiplied by 1,926 gives 3,194 acre feet, compared with 3,251 acre feet as given by Table II, a difference too slight to be considered.

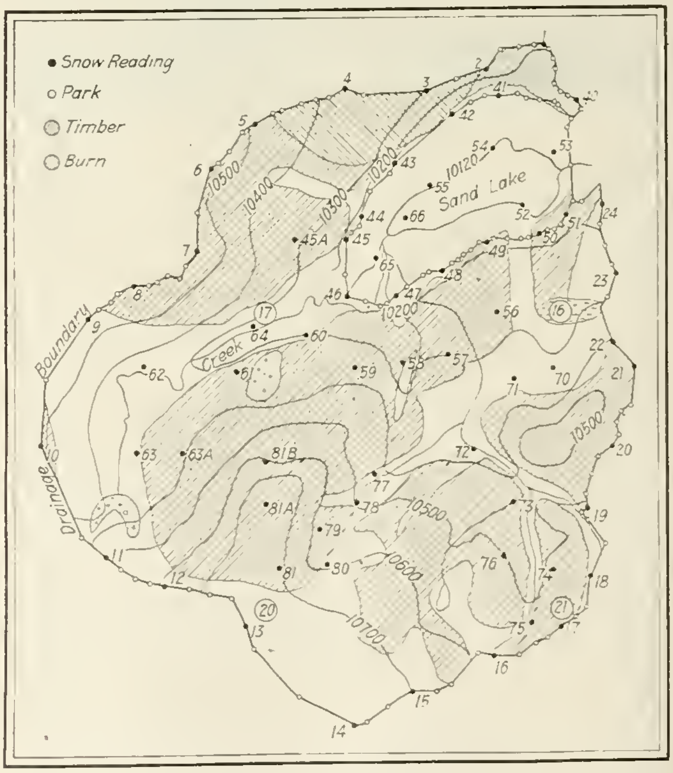


Fig. 1—Map of Snow Survey.

**Method of Making Survey.**—The survey was made by a party of two. The equipment carried consisted of the density tube and scale, alpine staff, compass and a long-handled shovel. The compass was used where side shots were desired. The end of the shovel was pointed so as to serve as a Jacob staff for the compass.

The density tube is a galvanized iron tube 2¾ in. in diameter and 50 in. long, with a saw tooth cutting edge at one end. A brass strip graduated in inches is riveted to the side of the tube. The scale is of aluminum and is graduated to read inches of water instead of pounds weight. The alpine staff is a staff about 7 ft. long, having a sharp iron point at one end and a hook at the other end.

The operation of making a density measurement is as follows: The alpine staff is stuck in the snow in an inclined position, the scale is then hung on the hook and the empty tube is weighed. The tube is then shoved down into the snow until the ground is reached, twisted around a few times, withdrawn with its core of snow and weighed. The weight of the empty tube subtracted from this latter weight gives the weight of the snow expressed in inches of water. Care must be taken after each weighing that the pointer of the scale returns to its zero reading.

**Cost.**—The cost of such a survey depends to a great extent upon local conditions and for that reason the following remarks are inserted:

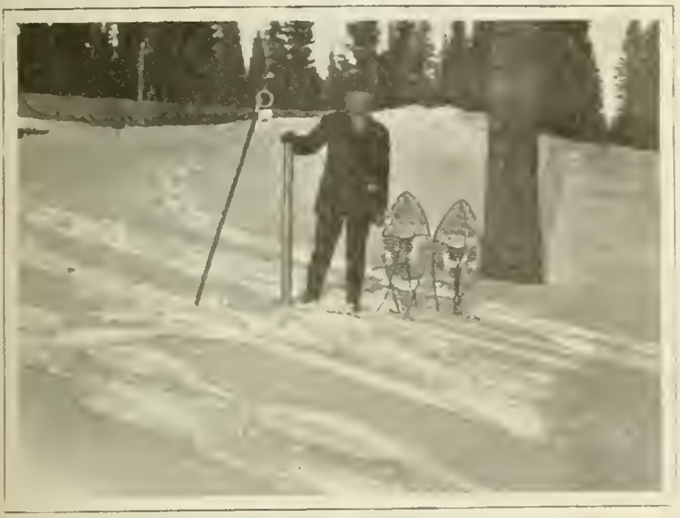


Fig. 2—View Showing Snow Scale Outfit.

The company's headquarters are in Rock River. A camp is maintained at Arlington, about 18 miles southwest of Rock River. A caretaker is stationed at this camp and cooks for any company employes stopping there. There is also stable room and feed for horses. At Sand Lake, about 35 miles southwest of Rock River, another camp is maintained, a caretaker also being stationed here.

The party making the survey drove from Rock River to Arlington, the remainder of the distance being traversed on snow shoes, the team remaining at Arlington.

The actual time is as follows:

| | Hours. | | Meals. | |
|---|---|---|---|---|
| | Men. | Team. | Men. | Team. |
| Two men and team, Rock River to Arlington, ½ day | 10 | 5 | 2 | 1 |
| Two men, Arlington to Sand Lake, 1 day, men taking a lunch and team remaining at Arl. | 20 | 10 | 6 | 3 |
| Two men making survey, 2 days | 40 | 20 | 12 | 6 |
| Two men, return to Arlington, ½ day | 10 | 5 | 4 | 2 |
| Two men and team, return to Rock River, ½ day | 10 | 5 | 2 | 1 |
| One man, maps and computations, 2 days | 20 | .. | .. | .. |
| Totals | 110 | 45 | 26 | 13 |

**Use and Value of Survey.**—The principle of the survey is to give an idea of the amount of water to be expected during the following season. This value is dependent upon the proportion of the drainage area covered by the survey. In this particular survey only a small portion of the area supplying water to the project was surveyed, Sand Lake being only a tributary to the main stream, Rock Creek. It is the intention to enlarge the survey from year to year until the major portion of the area is covered.

The value of the survey is also dependent upon the continuity of the record, as the current survey should be compared with those of previous years in order to realize its full benefit. It may be possible to approximate the run-off by observing the depth of the snow and its density at snow stakes placed at proper intervals over the area.

These stakes having been permanently located and a comparison of the average amount of snow shown at the stakes, with the results shown by snow surveys, may lead to the derivation of a coefficient accurate enough for computing the run-off.

It is also necessary to have some means of watching the rate at which the snow is melting and of gaging the stream supplied by the area, in order to form some idea as to the length of time the excess run-off may be expected to continue.

A gaging station has been installed in the outlet of Sand Lake, the location being shown on the map. The stream bed at this station has been concreted so as to give a permanent control. A Bristol automatic recording gage has also been installed. This gage gives the stage of the water and the company's engineers gage the station as often as possible and their results are checked by the Denver office of the U. S. Geological Survey.

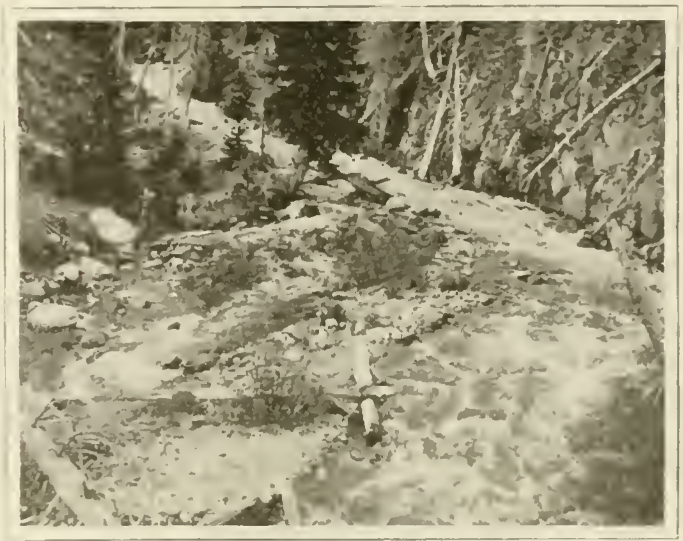


Fig. 3—View Showing Nature of Topography.

As before stated, the temperature and precipitation are taken every day and it is the intention to install an evaporation pan on the lake.

This data, combined with that given by the gaging station, will furnish an accurate check upon the reliability of the snow survey.

**General Remarks.**—A few general remarks for those not having any experience in this class of work may not be amiss. The survey should be made when the weather is cool and not changing, as it may lead to error if part of the survey is made on a cool day and the remainder on a warm day when the snow is melting and starting to run off.

It is also a great help if the weather is cold enough to freeze a crust on the snow. This facilitates walking and more points can be measured than when one has to wade through soft snow.

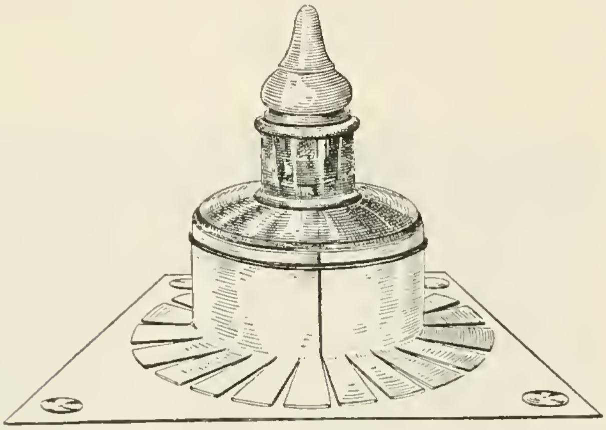
The choice of "feet" will be governed by experience and personal taste. It is probable that the inexperienced will have better success with web snowshoes than with skiis. It is more difficult to travel in a hilly country on skiis than on webs. A sandal which fastens to the snowshoe and into which the foot is inserted is much better than the thongs usually used for this purpose.

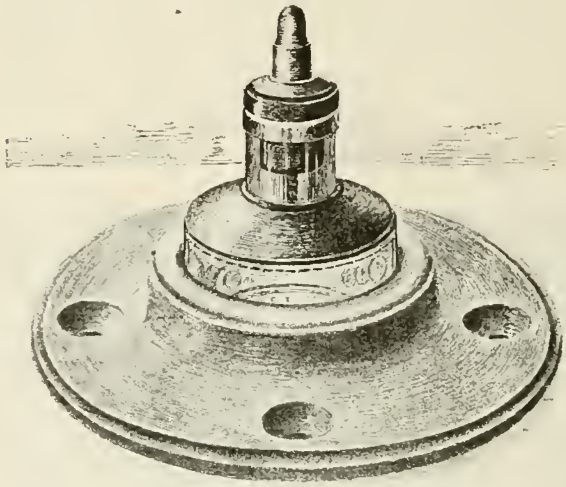
For footwear German socks and rubber packs or moccasins give good satisfaction. Mackinaw trousers should be worn, as it is almost impossible to wet them through and they are warm. No coat is necessary unless it be a Mackinaw or perhaps a leather vest for use in extremely cold weather. One travels much easier if he is cool and not encumbered with useless clothing.

Figure 2 gives a view of the snow scale hanging upon the alpine staff. The observer is holding the snow tube. The roof of one of the camp cabins can be seen in the background. Figure 3 is a scene along the creek which forms the outlet to Sand Lake and gives one an idea of the topography.

## MINOR DRAFTING ROOM DEVICES.

Efficiency in the drafting room is promoted by the use of many devices. These devices range from complete systems for handling work, or elaborate mechanical plants, to such small details as that of mending a torn tracing, and all are important in varying degrees. In this section of our Surveying, Drafting and Office Quarterly Issue we plan publication of the smaller drafting room devices which have been tried and found of merit. We request our draftsmen readers who find in the items which follow any help to return the aid by an account of some device used by him with success.


Paper Ink Bottle Holder.


Steam Pipe Floor Plate Ink Bottle Holder.

### Fadeless Blueprints.

After washing the ordinary blueprint spread it face up on a flat surface and paint, using an ordinary soft paint brush, with peroxide of hydrogen. This intensifies and "sets" the color and the print will not fade under any ordinary exposure.

### A Preventive for Warping Drawing Boards.

Warping of drawing boards may be prevented by treating the wood with shellac, as follows: Thin down the very best grade of white shellac with alcohol and with a brush rub it thoroughly into the wood, covering thoroughly both faces and all edges. This dressing is not a finish and should not leave a glossy surface; if such a surface results remove it by rubbing with alcohol. The purpose of the treatment is to prevent moisture entering the wood and so when the board has become filled with thumb tack holes a second treatment is desirable.

### Removing Eraser Fragments.

To remove easily the gummy eraser fragments after cleaning a drawing shake powdered chalk over the paper. The chalk dries up the eraser fragments so that they can be shaken or brushed off the drawing.

### Improvised Ink Bottle Holders.

An effective ink bottle holder may be improvised from an ordinary $1\frac{1}{2}$-in. steam pipe floor plate by setting the bottle in the pipe hole. Another resort where floor plates are not come at handily is two pieces of drawing paper arranged as follows: Make a cylinder of paper about twice as high as the barrel of the ink bottle and slip the ink bottle into one end and bind around with rubber bands. Slit the projecting end of the paper cylinder at a number of places and bend the strips outward at right angles, after which paste the strips to a flat paper base. Four thumb tacks through the paper base complete the bottle holder.

### Flattening a Long Rolled Drawing.

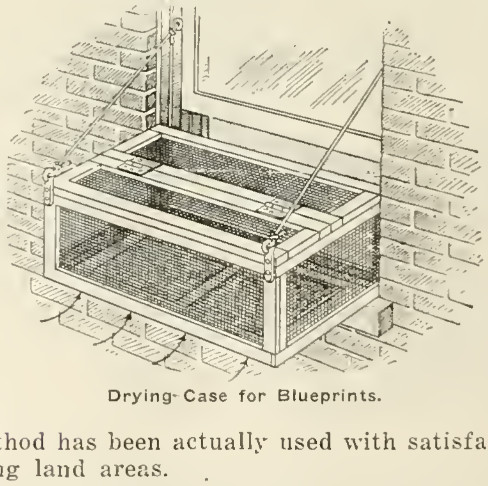
A drawing which has been so long rolled that it cannot be flattened by reverse rolling may be starched flat as follows: Unroll the drawing, lay it face down on a drawing board and pin it out flat. Boil a mixture of flour and water down to almost a thin dough and paint with it the back of the pinned drawing, being careful to rub the "paint" well into the paper. When the starch has dried the drawing can be unpinned and will remain flat.

### Spring Roll Shade Cover for Drawing Board.

To protect drawings left pinned to drawing boards an ordinary spring roll window shade can be used, as follows: To the top edge of the board hinge a strip of board so that it will fold down behind or under the drawing board. On this hinged strip mount a spring roll shade in the usual manner. To cover the drawing tilt up the hinged strip and pull down the shade. Oilcloth may be substituted for the ordinary window shade cloth and in place of the bottom stick a $\frac{1}{4}$-in. iron rod can be used; these are improvements over the standard window shade.

### Weighing Areas.

An approximate method of determining the areas of irregularly shaped surfaces is to plot the surface on drawing paper, cut away all the paper outside the platted surface, weigh the paper included in the plat and divide by the weight of a known unit area of the same paper. This method has been actually used with satisfaction for measuring land areas.


Drying-Case for Blueprints.

### Blueprint Drier for Indoor or Outdoor Use.

The case made of wooden strips fitted with panels of wire mesh, shown in the illustration, may be used on either the outer or inner sill of a window for the drying of blueprints. In warm weather it may be used in the position indicated, the prints being placed on the screened surface of the bottom. A free circulation of air is afforded and the prints dry quickly. When weather conditions do not permit its use outdoors, the drier may be set on the inner window sill over a radiator. Snap hooks with appropriate attachments on the window frame on both the inner and outer side, must be provided.—John Havekost in "Popular Mechanics."

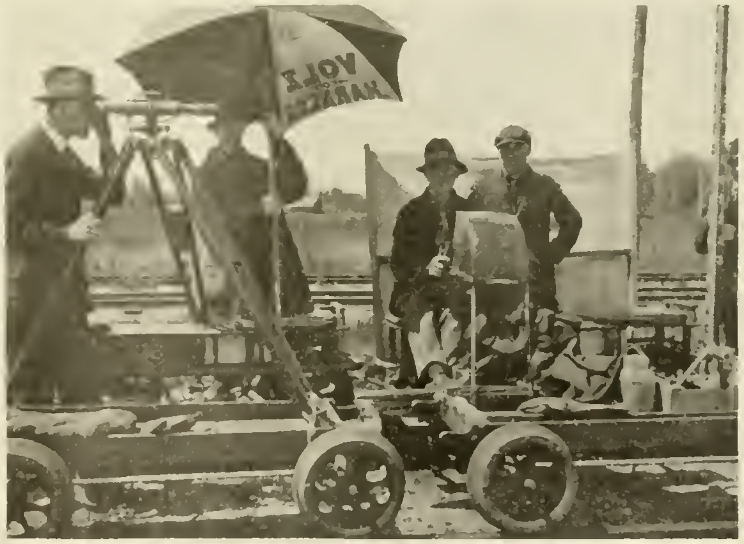
### Substituting Revised Details by Photographs.

Sometimes duplication work can be shortened by the aid of photography. For instance, some time ago it was made standard practice on a large road to replace the wooden pilots with short steel pilots, so designed that two engines could couple head on, without touching pilots, which was impossible with the wooden pilots. This particular road keeps an up-to-date locomotive classification book, copies of which are supplied to a large number of the officials, who return them to the mechanical engineer's office for revision, when so ordered. The writer was instructed to change the drawings, of the locomotives, from which etchings were made for this book, so as to show the new steel pilots on the locomotives and the changed dimensions to end of pilot and pulling face of knuckle. The drawings were on a sort of Bristol board and were to the same scale, so after making a drawing to scale of the new pilot and coupler, I proceeded to make tracings from it on tracing paper and pasted them in proper position over the old wooden pilots, after first pasting heavier paper over them, so that they would not show through the tracing paper. I soon saw that it would be a long and monotonous job to make the large number of these small tracings required, so I decided to make them without ink. I made four of the plot drawings in a space $3\frac{1}{4}$x$4\frac{1}{4}$ in. on tracing paper, to correspond to my photographic printing frames, and exposed them face down on a smooth developing paper and in this way obtained a "negative." From this negative face down, I printed, on the same kind of paper, the required number of pilot and coupler pictures which looked very much like ink drawings and being on opaque paper, were pasted directly in position on the drawings. Thus I saved a large percentage of the time which would have been required for the job.—Towson Rice in "Stevens Indicator."

## CAR-MOUNTED LEVEL AND ADDING MACHINE FOR PRECISE LEVELING.

An innovation in precise leveling which the engineers of the U. S. Coast and Geodetic Survey have found efficient and economical is exhibited by the accompanying illustrations. A Y-level, having the ordinary tripod, is mounted on a velocipede car and an adding machine on which the observations or level readings are recorded is mounted on a second car. This train proceeds along the railway taking levels in the same manner as when the ordinary practice of setting up the level on the ballast is followed. The first use of this car-mounted outfit was by Mr. J. H. Peters, in charge of a leveling party operating in Indiana and Michigan, but similar outfits have since been supplied to other parties. The work performed has shown accuracy equal to the older methods with increased speed and reduced unit costs. It is noted that the car mounting of the level calls for no material change in the regular tripod. This is set on the car when leveling is started and not removed until the completion of the day's work; the instrument remains in place even when the car is lifted from the track for passing trains. At the same time should occasion demand the level can be disconnected and used as it ordinarily is. The cars used are ordinary motor velocipede cars weighing some 350 lb. For these data from which this account has been prepared we are indebted to Mr. William Bowie, Chief Division of Geodesy, and M. E. Leston Jones, Superintendent, U. S. Coast and Geodetic Survey.

Adding Machine.



Two-Car Outfit.

## LOOSE LEAF NOTEBOOKS FOR WINNIPEG RIVER WATER POWER SURVEY.

In making surveys for the Winnipeg River water power development studies carried out by the water power branch of the Canadian Department of the Interior, the field work was plotted in camp as rapidly as completed, on 30x37-in. sheets. This immediate plotting on the ground was greatly aided by the loose-leaf system of field notes adopted throughout the work. Standard-size leather covers, with 5-in. by 8-in. fillers, suitably printed and ruled for transit, stadia, and level work, were provided. The great flexibility of the loose-leaf system proved of outstanding advantage to the rapid and efficient carrying on of the work, more especially as the results were being plotted into final shape as rapidly as the notes were available. The loose leaves also lent themselves most readily to a simple filing system, in which the records of the survey could be properly grouped, and be at all times available for instant reference. The engineer directing field operations was Mr. D. L. McLean, Ottawa, Ont.

## A NEW FABRIC FOR PHOTOPRINTS OF ORIGINAL SHEETS.

To reproduce by photography an original field sheet or other large subjects too large to be included on the largest size negative glass, which is 20x24 in., a negative is made of the entire drawing on a reduced scale, and by means of the photo-enlarging apparatus a print is made on bromide paper on the same scale as the original.

The bromide paper hitherto employed has several inconvenient features. After development, fixing, and washing it easily tears in handling and must be backed with muslin; its shrinkage in drying is not equal in all directions and results in distortion; and the slick gelatine surface is not adapted for either pencil or pen work.

The photographic section of the chart division, U. S. Coast and Geodetic Survey, has lately replaced the bromide paper with a new fabric, which is a great improvement over the former. As it is made of cloth, there is no need for backing the prints, and the delay and inconvenience formerly arising from this source is avoided. When dried after passing through the developing and washing solutions it shrinks to its original dimensions, being nearly free from distortion. The rougher texture of the surface makes it fairly good for both ink and pencil.—Coast Survey Bulletin, July, 1916.

## INCREASING DRAFTING ROOM EFFICIENCY BY IMPROVED FURNITURE DESIGN AND ARRANGEMENT.

A marked increase in drafting room efficiency has resulted from the arrangement and design of drawing tables and estimators' desks shown by the accompanying illustrations. The two views show the drafting room of the division of design of sewers and pavements of St. Louis, Mo., W. W. Horner, engineer in charge. As shown the drawing tables and the estimators' desks are arranged in two rows side by side, so that co-operation is possible with least travel. Figure 1 shows the general arrangement and Fig. 2 shows a close view of an estimator's desk. Figure 3 gives plans of one of the drawing tables, which are made to order at a cost of about $30. Ordinary high stools are used with the drafting tables and the necessary floor space is about 70 sq. ft. per table, allowing a distance of 24 in. between same and an aisle 4 ft. wide.

Figs. 1 and 2.—Drafting Room, Division of Sewers and Streets Design, St. Louis, Mo.

Probably of greater interest are the desks used by the estimators and designers of the Street Design Division. No drafting, except pencil work, is done by them. Prior to the installation of the new desks, they used the same equipment as the draftsmen.

From observation Mr. S. Sammelman, engineer in charge street design division, found that in the afternoon the men made more errors in their calculations, and further did not apply themselves diligently. This was due to being perched upon a high stool all day, which caused them to become physically tired to the detriment of the activity of their mental powers, so the more comfortable arrangement was substituted and an added degree of efficiency was very noticeable.

The tops of the desks are 32 in. wide by 72 in. long, and are ordinary standard stock "standing up" bookkeepers' desks with the legs cut down to a sitting height, which is about 30 in. from floor to top of desks. The cost was about $12 apiece with alterations made. The chairs are standard swivel desk chairs, costing $3.75 apiece. The floor space required is 50 sq. ft. per desk, allowing a 28-in. space between desks and an aisle 4 ft. wide.

We are indebted for the preceding information to Messrs. Horner and Sammelman.

## LOCATING SNOW SHED FIRES BY TRANSIT.*

Where the Southern Pacific railway curves the summit of the Sierras on the line from Sacramento, Cal., to Reno, Nev., there are 29 miles of timber snow sheds. In the dry summers of this region the greatest danger to these sheds is fire and watchmen and fire fighting trains are provided to guard against this danger.

It soon developed that, with watchmen located only in or on the shed, exposing forest fires could and did obtain considerable headway before discovery, and the desirability of a station from which a comprehensive view of the sheds and the adjacent country could be obtained was apparent. Such a point of vantage was found on the summit of Red Mountain, or Signal Peak, as the Government calls it. This mountain, whose summit is at an elevation of 7,860 ft. above the level of the sea, stands on the north side of the main canon, on the south side of which the road winds its way through the mountains,

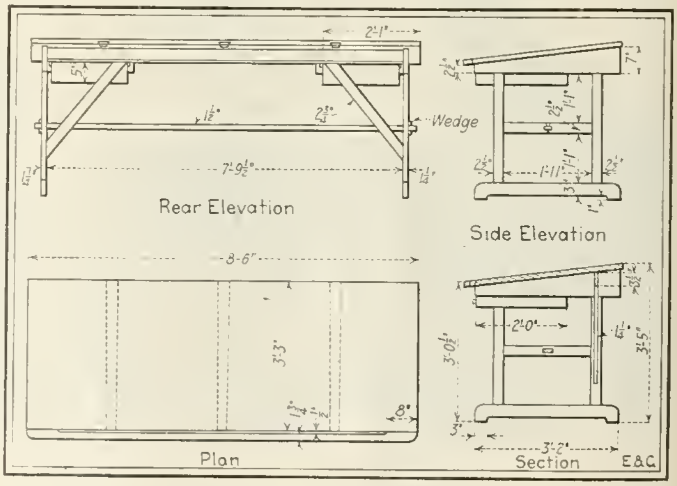


Fig. 3—Plans of Drawing Table, Division of Sewers and Streets Design, St. Louis, Mo.

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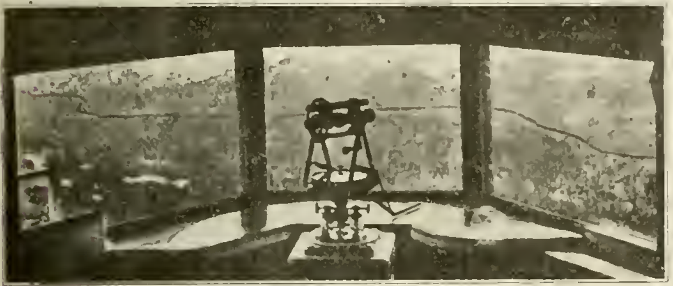
*From a paper by Niles Searls in the July Quarterly of the National Fire Protection Association.

This summit is at an average elevation of 1,800 ft. above the track, in the shed district, and distant therefrom 1½ to 12 miles. An observatory building was erected on the mountain top.

In the clear air of this altitude, a good pair of eyes and constant watchfulness are all that is necessary during the normal daylight conditions, but at night, or at any time when the clear view of the shed is impossible, it becomes necessary to provide some means by which the many fires appearing can be accurately located in reference to the shed. To accomplish this, the apparatus, as shown in the accompanying picture of the interior of the bay, is installed. This consists of a transit, mounted on a fixed pier, in the center of the bay, and a map etched on a silver-plated copper plate located on a shelf in front of the transit. The shed line on this map is inlaid with black enamel, and along this line is indicated in different colored enamels each station, tunnel, mile post, signal box, etc., in its proper location. Over this map swings a knife-blade pointer attached to, and coinciding with the axis of the transit.

On the plate glass of the window, and opposite the cross-hairs of the finder, is etched an opaque line exactly coinciding with the shed. This line shows rather faintly in the photograph of the interior. This line is so located that when the cross-hairs of the transit cut the shed, the cross-hairs of the finder cut a corresponding portion of the etched line. This line is located opposite the finder, which is a simple peep tube provided with cross-hairs, for the reason that it would be impossible to focus the glass of the transit on this line at such short range, and also to prevent the blurring of the shed view through the transit which would be caused by the presence of an opaque line so close to the object glass.



Transit Station for Locating Snow Shed Fires, Southern Pacific Ry.

The operator, at night, sits in this bay in semi-darkness and keeps a general lookout over the surrounding country. On observing a fire, or a suspicious light, he turns the transit onto it and then presses a button which controls a small battery-operated electric light, illuminating the map and the etched line, the reflection of this light from the plate glass of the window also serving to illuminate the cross-hairs of both transit and finder. Under these conditions of illumination, a glance through the finder at the etched line determines whether the fire is above, below or in the shed and the position of the pointer indicates its exact location along the shed. If the fire is a small campfire, too close to the shed, word is sent to the nearest section headquarters and men sent to move the parties to a safe distance and extinguish the offending fire. In case of an actual fire in shed, or of an exposure fire of magnitude, the fire trains are called, the ones nearest the fire going directly to the reported scene, and the others closing in as in regular fire department service.

As a sample of the accuracy with which even small fires can be located from this station, I will cite an instance that occurred on Oct. 2, 1915. On the evening of that date, a section foreman took it into his head to sharpen some track chisels, and, for that purpose, took a portable forge and set it up outside of the shed, but in direct line between the shed and the observatory, and proceeded to kindle a fire in the forge. This fire was observed by the watchman, and, being apparently in the shed, the fire train was called, ran two miles and stopped exactly opposite the location of the forge before the chisels had been brought to a working heat.

At another time the agent at Midas, a station well below the shed district and at a distance of about 18 miles from the observatory, received a message from the watchman stating that a small fire was burning "about 10 ft. back of the freight house" at his station. Investigation disclosed a tramp's campfire at the point indicated. Other instances could be given, but these serve to show what the installation is capable of accomplishing.

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## METHODS AND COST OF REPRODUCING AND REDUCING ENGINEERING DRAWINGS.

Contributed by J. N. Cohen, Designing Engineer, Syracuse Intercepting Sewer Board, Syracuse, N. Y.

In the evolution of engineering practice there has been developed a group of methods for reproducing and reducing engineering drawings which, it is felt, because of their utility to engineers, merits presentation and discussion. It is the intention of this article to describe briefly the various processes, noting their possibilities and limitations, and to give such hints in their utilization as have been found from experience to be serviceable.

Some of the processes of reproducing drawings are very well known, and these will be but briefly mentioned; others are not quite as well known as they should be, and will be treated somewhat more fully.

In the past few years the utility of small sized drawings for construction purposes has received recognition to such an extent that quite a number of more or less complicated structures have been built from plans on sheets 8½x11 in. or thereabouts. Many engineers feel, however, that their drawings are of such complex nature that to lay them out on 8½x11-in. sheets would require either the undesirable cutting up of a structure into sections, or the use of a very small scale which would bring the entire structure on the reduced size sheet. The scale, however, would generally be so small as to preclude, because of the draughting difficulties, the possibility of showing all the essential features. Desiring to avoid the ordinarily large and clumsy sheets and to have the numerous other advantages of small sheets, engineers have taken to the reduction of their drawings.

Small sheets are of unquestionable utility in the field and shop; in the preliminary steps leading up to the award of a contract, prospective bidders find their frequently thankless jobs of preparing intelligent bids greatly facilitated by a set of contract plans that are clear, complete and yet so small that they can be readily handled. To the engineer small sheets are also of great service, for they reduce the bulk of his accumulating records, make all his drawings handy for future reference and furnish him a means of exhibiting many samples of his work to a busy prospective client in a short space of time. The small sheet intensifies the drawing, bringing within the limits of vision the entire drawing and showing it all at a glance. In a word, the small sheet is the acme of engineering drawing.

Reduced drawings are of service in embellishing technical reports to bodies of laymen, such as committees of civic organizations, council committees and other similar governmental bodies. The value of the diagram as a concise presentation of related data need not be pointed out to the engineer, but the use of large scale diagrams reduced to 8½x11 in. sheets and their embodiment in typewritten reports, that will perhaps never be published in printed form, deserves consideration. Large maps, on which, for instance, a number of projects can be shown that are possible for the attainment of a desired result, can be very readily reduced by several of the processes outlined below, and will give a wealth of detail within the compass of a letter-size, or even smaller sheet, that is attainable in no other way. The maps of the U. S. Geological Survey, so valuable to the practicing engineer, lend themselves very readily to such reduction.

And here it might be well to mention in passing that the use of pictures in technical reports by engineers is such an effective means of making clear, lengthy descriptions that such use should be more common than it is. Technical reports on proposed projects would be made readable, and therefore more frequently and interestedly read by those non-technical officials and individuals for whom the reports are intended, if photographic illustrations were interspersed through pages of matter that would perhaps otherwise be "dry" reading. In other words, the engineer should attempt in some manner to keep pace with the manufacturer who equips his sales-agents with portable motion-picture machines for the effective and appealing presentation of his processes or products.

The methods of reproduction and reduction to be discussed are listed below, and while the list is not exhaustive, it is believed that it does contain most of the processes that are of interest and service to the engineer.

REPRODUCTION.

1. Blueprints.
2. Van Dyke prints.
3. Blue on white prints.
4. Lithoprints.
5. Ink-ograf prints.
6. Carbon copies.
7. Hektograph prints.

REDUCTION.

1. Photographic prints.
2. Rectigraph prints.
3. Photo-lithographs.

Ink-ograf prints.

5. Zinc-cut prints.

### Drafting Hints.

Before considering the reproduction and reduction processes in detail, it might be well to summarize those features of the technique of drafting upon which successful and satisfactory results so largely depend.

In the preparation of drawings for reproduction only the usual precautions about the weights of lines and lettering need be observed, and a drawing that is good in the accepted sense will usually reproduce well. In the preparation of drawings for reduction, however, it will be necessary to take the various precautions hereinafter mentioned.

The lettering on a drawing should at all times be clear and clean, but for reduction work it is imperative that the individual letters be well shaped and of such height that when the drawing is reduced they will not become too small to be readily legible. While it is not always possible to know in advance the amount of reduction to which the drawing will be subjected, yet it is desirable so to proportion the letters that the maximum reasonable reduction will keep them at least 1 millimeter high. It has been found from long experience with the reduction of drawings that if all the subordinate lettering, such as notes and dimensions, be made about ⅛ in. high, normal reduction will not greatly affect their legibility.

Titles and sub-titles generally come out very plainly in reduced drawings. In the reproductions of such portions of a title as are standard for a set of drawings, or in the reproduction of such portions of a drawing as are standard, such as border lines, sheet number blanks, professional cards or other stock lettering, the St. George process of lithography on tracing cloth is a very serviceable, simple and comparatively inexpensive method that will save much labor, time and expense in even the smallest of drafting rooms. This process will be discussed later on under "Reproducing Drawings."

Fine line lettering for drawings to be reduced is highly objectionable, as is all fine line work. For lettering, the finer ball-point pens are recommended, as they produce a stroke that is smooth and sturdy.

One excellent time and labor saver that can be adapted for use in the drafting room is the gummed letter. These letters are obtainable at stationers in a large variety of heights and in several styles, are machine-made and perfectly formed of block, opaque paper, gummed on one side, ready to be attached, after slight moistening, to tracing cloth or paper. Large title pages can be prepared in one-half to one-third of the time required for ordinary hand work and the prints from the pasted letters are in many ways superior to the latter in clearness. These letters are made by the Tablet & Ticket Co. of New York City, and their use in office buildings for directories, and in public exhibits for placard work is generally known. Their use in drafting rooms will become greater as their serviceableness is tried out.

There are rare occasions in the preparation of drawings to be reduced when it becomes desirable to know just how a certain feature or detail will appear on the finished drawing. A reducing glass, whose purpose is of course the opposite of the ordinary magnifying glass, fills this need nicely.

Inventors and others who are acquainted with drafting room procedure have in recent years been seeking some simple means of transparentizing paper which is of sufficient body to stand drafting work, including erasures, and on which pencil drawings can easily be prepared, so as to eliminate the expense, the time and the sources of error that come with tracing. There are a number of fluids on the market known as transparentizers, but their use is not very common as the results are not completely satisfactory. These fluids are applied to the paper after the pencil drawing has been completed, and usually are a mixture of benzine and paraffine.

A few years ago there was placed upon the market a transparentizing machine which treats heavy tracing paper with a solution that renders the fairly opaque paper sufficiently translucent to enable blueprint copies to be made from the pencil drawing. Such machines are particularly adapted to large engineering organizations where reproductions alone are required, but in the consulting engineer's office, and in other offices, where the drawings prepared later become the property of the client, the tracing of drawings on cloth can hardly be altogether eliminated.

The blueprints produced from transparentized drawings are of a quality sufficiently good for the shop or field, but of course are not quite as good as those from an India ink tracing. The pencil drawing needs to be worked up complete and with all detail; nevertheless, the saving in time is tremendous compared with the tracing system, and the saving in expense is said easily to pay the cost of the machine or "mechanigraph" as it is called, several times over in a year of use.

### The Production of Drawings.

**Blueprints.**—The ordinary process of reproducing drawings by blueprinting is too well known to need more than mention. It is desired, however, to point out that by grading the weights of the blueprint paper used their utility to the engineer can be increased. For a record set of drawings to be filed in an office where space is valuable—a rather general condition—a surprising saving in bulk can be attained by the use of thin paper blueprints. These prints cost no more than the ordinary, medium weight paper and require no more care in handling. For field use or construction work, prints on heavy paper, or better still on cloth, are the most serviceable. Where prints are likely to be exposed to the weather a thin coat of varnish should serve to protect the chemical coating and increase the useful life of the print. Blueprints that are likely to be much exposed to the sun should be very thoroughly washed after printing. The cost of blueprints ranges from 1½ ct. per square foot upwards, and the process is about the cheapest of all the processes used to reproduce drawings in limited quantities.

**Van Dyke or Brown Prints.**—The method of reproducing tracings by the Van Dyke or brown-line process is gradually being displaced by the newer and more satisfactory methods of reproduction. Because of the negative print which is an essential part of the process, the cost is rather high. The positive print, made from the negative, suffers a double reduction from the original size and is, on that account, sometimes rather troublesome in scaling.

The white ground of the positive is never quite white and frequently rather yellow, but the dark brown lines are easily matched with India ink, and for that reason additions to the positive can readily be made. The paper takes colors easily and prints are therefore of service where different classes of work are to be distinguished by various colors. A rather serious objection to brownprints is the friability of the paper, causing it to tear easily with but little handling.

The process of making these prints is as follows: The tracing and sentitized paper are placed in a frame and exposed to the light (either sunlight or electric light), the tracing being reversed so that the print will be a negative. After washing, fixing and drying, prints are made from the negative, which has white lines on a deep brown ground; these positive prints, as already stated, have brown lines on white ground. Erasures from the positive can be made with potassium cyanide, but the deadly nature of this chemical makes its careful use highly imperative.

Many engineering offices use the negative as a record of the original tracing, and keep it on file while the tracings are either stored in a fireproof vault or sent to the client.

The negative costs about 5 ct. per square foot, and the positive about the same, making the initial cost of one reproduction about 10 ct. per square foot. Of course, if more than one positive is printed, the cost of the negative per positive print gradually decreases.

**Blue on White Prints.**—The blueprint obtained from a Van Dyke negative, used instead of a tracing, is termed a blue-on-white print because the lines are blue on a whitish background. The prints are made in the ordinary blueprint way, but require a somewhat longer exposure in the printing frame or machine. For this reason they are slightly more expensive, particularly when made in electric-light printing machines.

The blue-on-white prints, when carefully made, are neat and attractive, and have a number of commendable features. They will take wax, crayon or water colors, can be worked upon with blue ink that can be mixed to match the print, and can, of course, be obtained on any weight of paper or on cloth. They cost about 2 ct. per square foot of print.

**Lithoprints.**—One of the newest of the methods of reproducing drawings is known as the lithoprint process, from its analogy to the printing process of lithography It is not only one of the latest, but also one of the very best of the many methods previously described. Its prime utility lies in its great flexibility, and by means of it prints of tracings can be produced upon paper of any weight or texture, including bond and tracing papers and upon cloth, both opaque and transparent.

The process of producing lithoprints is a simple one to describe, but its execution requires experience, skill and, what is of greater importance, the possession of a trade secret which is zealously guarded.

The steps in the making of a lithoprint are about as follows: The tracing, made in the ordinary way, is first blueprinted. All further work is done with this blueprint, the tracing being no longer handled. The blueprint is not, however, treated in the usual way; instead the coated, exposed face is placed upon a slab of gelatine and other substances of unknown composition, similar in nature to the gelatinous slab of the hektograph process, later described, and pressed down very smoothly to remove all air bubbles. Where the exposed lines of the blueprint come in contact with the gelatinous compound, an action takes place, chemical or mechanical, it cannot be definitely stated which, that leaves a mark upon the slab when the blueprint is peeled off. After removal the blueprint can be washed in the ordinary way and used as a blueprint copy of the tracing.

The surface of the slab is then gone over with an ink roller coated with printers' black ink; this ink adheres only to the marks or lines made by the unexposed chemicals of the blueprint, and when a sheet of paper or cloth is pressed upon the slab, the ink prints upon it, making a black line copy that is very sharp and clear.

As the litho-impression is made upon the slab before the blueprint has been washed, and therefore not subjected to shrinking, the lithoprints are exact reproductions of the original tracing, making them valuable in work that requires much scaling of the drawing. Another advantage of a lithoprint lies in its lines being black, which can, therefore, be readily duplicated with India ink, making it a simple matter to add to the drawing should such need arise. If a lithoprint is not too old, and particularly upon its receipt from the printer, erasures and changes can very readily be made. In fact, when the print is fresh, it should be carefully handled. India ink additions, when carefully made, may be detected only upon close scrutiny.

Another distinct advantage that is inherent in the lithoprint process lies in the fact that any portion of a drawing or any lettering can be excluded from the print, should it be so desired. This is accomplished by blocking out from the slab the parts to be omitted, and it can be done without affecting the quality or appearance of the print. Advantage can frequently be taken of this property in offices where the same drawing with different subjoined data or titles can be used on various pieces of work. Lithoprints upon paper are also very handy in map work where coloring is desired. The ink, when it is thoroughly dry, is waterproof and is not affected by the brush.

Lithoprints have many serviceable and commendable features, but they have the drawback of their comparative expensiveness. They cost about 8 ct. per square foot for a single print to 4 ct. per square foot if four or more prints of the same tracing are required; for cloth prints the costs are 10 ct. to 6 ct. per square foot. Tracing cloth lithoprints cost 16 ct. per square foot. From this it will be seen that if ordered in limited quantities, while they do not compete with blue prints in price, yet the cost of lithoprints is not too great when their utility, flexibility and above all, undeniably attractive appearance is taken into consideration.

The E. G. Soltmann Co. of New York have developed a process analogous to lithoprinting which employs a zinc plate instead of a gelatinous slab. This enables them to obtain many more copies, which they call ink-o-graf prints, than is possible with the former process, and they also claim a higher grade of work. Their prices, however, are slightly higher, ranging from 10 ct. per square foot for 25 copies to 6 ct. per square foot for 100 copies for 12x18-in. sheets. For larger sizes the prices range from 6 ct. per square foot for a minimum of 12 copies to 3 ct. per square foot for 100 copies.

The lithoprint in reduction work, where its serviceableness is also beyond question, will be discussed under "Reduction of Drawings."

**Pencil Carbon Copies.**—A duplicate copy of a sketch prepared to accompany a letter is generally required in engineering offices for the files, and sometimes limited time or other circumstances prohibit the making of a blueprint copy. A simple method of obtaining one or two copies of such a hurried sketch is gone over with a hard pencil, or else directly prepared on the sheet, underneath which has been placed the carbon and blank sheets. The transference of portions of maps, drawings, etc., upon comparatively opaque paper of such weight or color that tracing through is impossible is easily performed with the stylus and carbon paper. The carbon paper prepared for pencil copying is the best for such work, but fresh sheets of ordinary typewriter carbon serve almost equally as well. The important point to remember in applying this process is that its results are due entirely to pressure.

**Tracing Cloth Blanks.**—As previously mentioned, the St. George Lithographic process for tracing cloth is serviceable and comparatively inexpensive. Its use is most desirable in large engineering offices, but even small offices where only limited quantities of work are performed will find it advantageous.

The Henry V. St. George Co. of New York City, prepare blank tracing cloth sheets cut to size and printed with any lettering desired, with the border lines ruled and with any other drafting that will prove of service. They employ a lithographic process and use a special ink that will stand severe handling after drying without affecting the quality of the lines. The cost of printing border lines, etc., upon cut sheets, is more than balanced by the elimination of the waste of a few inches of expensive tracing cloth every time a sheet is cut by hand in the drafting room and as the time consumed to rule border lines and do whatever stock lettering is required is altogether saved, the process is of course a very economical one to employ.

**Hektograph Prints.**—The Dous "Tip Top" Duplicator and other similar appliances for reproducing letters, etc., based on the hektograph principle are in use in many offices, and can, without any modification, be used for the reproduction of sketches as well.

The hektograph in its simplest form is a sheet metal pan filled with a jelly-like compound that has the property of absorbing hektographic ink in such a way that when paper is pressed upon the slab the ink makes a clear impression upon it. About 40 copies can easily be made, the later copies, of course, being the fainter, but this can be partly overcome by allowing the print to remain in contact for a longer period. The hektograph outfits can be obtained at stationers in a variety of sizes; the 9 in. by 12 in. size costs about 75 ct. The ink is not much more costly than ordinary writing fluid, and lasts for a long time. The cost of hektograph prints, therefore, is almost a negligible factor.

They are not used to a great extent because they are not quite as neat as the products of other methods of reproduction, but in offices and shops where appearance is not a controlling factor, and where the quantity of prints required runs up the total comparative costs it would be worth while trying out the hektograph. On field work, away from blueprinting companies, the hektograph, an old yet serviceable means of making copies, should be particularly useful to the resident engineer.

Drawings to be hektographed are best prepared on tracing cloth in the usual way, except hektograph ink is used in place of India ink. A little experience with the materials will make the limitations of the process clear, and when not too much is expected of it, the hektograph can render good service in the reproduction of sketches and simple drawings.

### The Reduction of Drawings.

**Photographs of Plans.**—The camera is probably the greatest adjunct to modern drafting room equipment. With its aid drawings can be rapidly reproduced in reduced form without loss of clearness or legibility and without prohibitive expense.

The tracings to be reduced are first photographed upon glass or paper negatives. It is desirable to have this done by skilled photographers, as the work involves technicalities not readily mastered by the amateur. With sufficient experience, however, the ordinary amateur kodak operator can learn plan photography well enough for his own service, but for commercial work the professional is preferable.

The glass negatives can, of course, be any size desired, due consideration being given to the amount of reduction entailed, but the 5x7 in. and 8x10 in. sizes are the most popular. The most satisfactory size in general is the 8x10 in. printed on larger paper and trimmed to 8½ in. by 11 in. An 8x10 in. glass negative costs 75 ct. and the 8½x11 in. print 17 ct. In an engineering office where the glass negatives accumulate, a simple filing system of some sort is required in order to make them available. It is best to place each negative in a separate envelope, properly marked outside, and then to file the negatives vertically in a box. Otherwise negatives will be scratched through handling and when piled up horizontally the lower ones will sometimes badly crack because of the pressure of negatives above.

For the finest work prints from the negatives should be made on glossy paper. This paper brings out every detail, but requires some manipulation in order to obtain results that are uniformly dark all over when the negatives are not of even tone. This is especially so with the larger negatives, such as the 8x10-in., and for this reason the professional photographer is best qualified for the work. Blueprints, however, are a great deal cheaper, can be very easily made by the blueprinter at one-fourth to one-sixth the cost of photographic prints, and are excellent to work with. A still finer grade of blueprint work can be obtained by the use of the best quality blueprint paper, which is ordinarily kept in stock at photographic supply stores.

When a set of tracings are not available for photographic reduction, blueprints, preferably deeply printed, will serve. The difference in the results, however, is that the photographic negative from a blueprint will give white lines on a dark background when printed. This is not a serious objection from the standpoint of clearness.

Lithoprint reductions can be obtained from photographic negatives, by using a blueprint made from the glass negative, in the manner detailed under "Lithoprints," and where more than a few copies are desired, the method is economical, compared to photographic prints and gives neat black line results on a white ground. Lithoprint reduction can also be obtained by the ink-o-graf process, previously discussed. Lithoprint reduced drawings bound in 6x9-in. or 8½x11-in. pamphlets are becoming deservedly popular for contract drawings.

The camera can also be used for the enlargement of drawings, which is sometimes required for public exhibition work. Here the original is photographed on a glass plate of convenient size and then an enlargement made. Expense and time can be saved by this method where small, intricate drawings need to be shown to large groups of people, such as at council meetings, technical meetings, lectures and exhibitions, when a stereoptican is not available.

**Rectigraph Prints.**—Lare engineering organizations are finding it economical and advantageous to install as part of their drafting room equipment a rectigraph or photostat machine, but smaller firms can have their work done by commercial rectigraph operators. The rectigraph process is simply photography directly upon sensitized paper without the intervention of the usual glass negative, thereby eliminating that expense. The rectigraph machines now on the market are largely automatic in character and prints can, in from one to two minutes, be exposed, fixed, washed and dried by the turning of a crank.

Any kind or size of a drawing can be handled and reproduced in reduced or enlarged form by this process. Other names by which this process is sometimes called are photoprinting or photostat work. The rectigraph is of prime utility in speedily obtaining reproductions or reductions of drawings that cannot be reproduced by the other common processes. By means of this machine copies, full size, reduced or enlarged, as may be desired, can be obtained from blueprints, from drawings on opaque paper or from plates in books and magazines.

The rectigraph or photoprint process is well adapted to the reduction of pencil drawings. The results from white paper drawings are very good and from yellow detail paper, which one would expect would hinder the photographic work, the results are almost equally satisfactory. When reproductions of a drawing are wanted in a hurry, the rectigraph becomes almost invaluable as it eliminates the necessity of making a tracing.

The rectigraph process employs bromide paper, resulting in dark brown lines. A print from a tracing is a negative; that is, the black lines of the tracing become white lines on the dark brown background of the rectigraph print. If prints with black lines on white ground are desired, reproductions are then made from the negative. Copy prints from blueprints are positives; that is, dark lines on white ground; in this case the blueprint serves as the negative and the results produced are very satisfactory.

The capacity of the largest rectigraph machine is a finished print, 18x24 in.; the smallest size ordinarily made is 6x12 in. The 10x12 print trimmed to 8½x11 in. is the size most commonly used, and its cost ranges on a sliding scale, from 20 ct. for a single print to 12½ ct. per print when 25 copies of the same print are required.

**Photo-Lithography.**—The photo-lithographic process for the reproduction of reduced engineering drawings, as developed by Hart of New York, produces prints that are of the finest grade of work. It has been employed by the New York Board of Water Supply and other large engineering organizations for the reproduction of their contract plans with results that have been highly satisfactory. It is a development of ordinary lithography and the process is such that color printing on maps, etc., can be performed if desired.

The first step in the process is the photographing of the tracing to be reproduced upon a glass negative. At this time the reduction is also made, and should it be desired to reproduce a very large map upon a sheet of a size greater than the size of the camera, as many negatives as are necessary are made of portions of the drawing and these are later matched together.

From the glass negative a positive print is then made upon paper that is specially prepared and sensitized for the process and the print treated with gelatine and other materials involved in the technique of lithography and then applied to the lithographic stone. The impression from the print to the stone is transferred by pressure and after going over with gum arabic and ink, the stone is ready for printing. Additions or alterations can be readily made at this time. The prints are then run off in a flatbed press to the required amount and the stone then cleaned for another drawing or else filed for a second edition, should that be likely.

The process is not an inexpensive one and is not economical to employ when less than 50 to 100 copies are required. A 20x28-in. tracing reduced to 8x10 in. and 100 prints run off therefrom on paper will cost about $6, or 6 ct. per print. A single blueprint of the original tracing will cost about the same, though the result will of course differ in many ways from the lithograph print. For larger number of copies the process, however, will give results that are highly satisfactory from every viewpoint.

**Zinc Cuts.**—The zinc cut method of reproducing reduced drawings is practically limited to technical periodicals and other printed publications where hundreds and possibly thousands of copies are required. The preparation of drawings for such work has a technique all its own, but outside of stating that very fine lines and lettering are dimmed and sometimes lost in the reduction process, which is a photographic one, nothing else will here be said concerning it.

Nevertheless, zinc cuts can be of service in engineering drafting rooms for the preparation of blank forms used in computation and sketching, as most of this paper is ruled in certain prescribed ways and has various printed headings and blanks. By preparing an original by hand and then making a zinc cut from it, as many copies as desired can then be printed and the cut stored for future use.

In printed engineering reports the zinc cut should find favor as a ready and cheap means of reproducing extensive typewritten tabular data. They can be prepared directly from a typewritten sheet made with a dark ribbon. Elisions and simple changes are possible and the cuts can be very rapidly made. They have, of course, a potential value after the publication of the report, as another edition of the tables might later be desired.

The initial cost of a zinc cut print is rather high, as the minimum price is 50 ct. per cut, and the unit price about 5 ct. per square inch of cut. This makes a 5x7-in. cut cost $1.75, but when the cost of the cut is divided by the many copies produced from it, the cost per copy rapidly decreases.

### Conclusions.

When the question of reproducing or reducing drawings is presented to the engineer he should bear in mind that each of the processes discussed above has various advantages and disadvantages as well as other natural limitations, some of which have been pointed out. The decision to employ any particular process can be best determined only after a careful consideration of the quantity of prints desired, the quality, finish and appearance of the work, the speed of production possible, the durability of the product, and lastly upon the cost. With all these factors considered the engineer will be better able to decide upon that process which will produce the prints required in the least time, which will be of a quality best suited to their future use and at a minimum total expenditure.

## A SIMPLE AND EFFICIENT COST KEEPING SYSTEM FOR CONCRETE CONSTRUCTION.*

The object of this thesis is to outline the cost keeping methods used by the Ferro-Concrete Construction Co., general contractors who specialize in erecting concrete buildings. By gradual stages this firm has obtained a workable system without allowing it to become cumbersome. Too much detail is a waste of money, but enough detail must be had to make the cost complete and as definite as possible.

### Recording Labor.

Every contractor realizes the necessity of care in keeping the men's time accurately so as to avoid overpayment or underpayment. The former is a direct loss, the latter indirect, as it causes discontent and dissatisfaction which will drive away the better class of labor.

The usual custom is a time-book kept by the time-keeper, and this is often the sole record of the hours put in by the men. A better way is the time-clock, where every man records his own time. It requires careful supervision on construction work as overpayment may result. The time-keeper records the hours, rate, and amount of money due each man and renders weekly payrolls to the main office from which the men are paid. At one time we required these payrolls to indicate how much of each man's wages was to be charged to each main heading, Forms, Concrete, Steel, Finish, etc. This was a matter of memory with the average time-keeper and after the payroll was made up he hurriedly went through and noted what he thought would be a fair division. Few kept any record to even guide their judgment in this direction.

The present system brings us a weekly payroll as be-

Form No. 101

F. C. C. CO.

LOCATION—Graydon Garage—Quantities for Cost Dept. Est. or Job No._____
DATE 4/22/16 Fig. By H. R. Gabriel Ch'k'd By__________Sheet No.________

*SUMMARY*

| | 1-1½-3 Conc. C. Y. | 1-2-4 Conc. C. Y. | Forms Sq. Ft. | Steel Lbs. |
|---|---|---|---|---|
| All Footings | | 30 | 570 | 24870 |
| Interior Cols. Top of Fts. to 1st Fl. | 21 | | 920 | |
| Walls and Wall Cols. to 1st Fl. Elev. | | 258 | 11840 | |
| First Floor | | 136 | 10190 | 29440 |
| Cols. 1st to 2nd | 67 | | 3660 | 5545 |
| Second Fl. | | 144 | 11030 | 29440 |
| Cols. 2nd to 3rd | 42 | | 2420 | 5665 |
| Third Floor | | 153 | 11850 | 29440 |
| Cols. 3rd to 4th | 35 | | 2200 | 4730 |
| 4th Fl. | | 153 | 11850 | 29440 |
| Cols 4th to Roof | 35 | | 2250 | 4105 |
| Roof Beams, Girders and Slabs | | 131 | 11730 | 13225 |
| | 200 | 1005 | 80500 | 175900 |

*BRICKWORK*

| | Fire Brick | Common Brick | Face Brick |
|---|---|---|---|
| | M. | M. | M. |
| Basement to 1st | 1.0 | 22.8 | — |
| 1st to 2nd | 1.0 | 57.6 | 1.3 |
| 2nd to 3rd | — | 53.1 | 1.4 |
| 3rd to 4th | — | 54.4 | 1.9 |
| 4th to Roof | — | 55.6 | 2.2 |
| Pent House | — | 25.5 | — |

1700 Pcs. 8" Terra Cotta Tile for Second Floor.

Form I.

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*Condensed from a thesis prepared by Harry J. Gould, Cost Engineer, Ferro-Concrete Construction Co. Cincinnati, Ohio.

F. C. C. CO.

LOCATION—282 Graydon Estate Garage

Est. or Job No.________

Note—Walls till 5-4—wheelbarrow work

DATE________ Fig. By________ Ch'k'd By________ Sheet No.

Hoist used 5-4 on

Ci

| 1916 | Quant. | Unit | Cost | Total Unit |
|---|---|---|---|---|
| 4-6 | 32.9 | .764 | 25 20 | |
| 4-13 | 72.7 | .793 | 57 90 | |
| | 105.6 | | 43 10 | .784 |
| 4-25 | 48 | 1.16 | 55 30 | |
| | 153.6 | | 138 40 | .90 |
| 4-27 | 38 | .61 | 23 40 | |
| | 191.6 | | 161 80 | 84 |
| 5-4 | 24 | .54 | 13 00 | |
| | 215.6 | | 174 80 | .81 |

Co

| | | | | Sax Cement | Sax per yard |
|---|---|---|---|---|---|
| 4-6 | 1.09 | 35 00 | | 181 | 5.50 |
| 4-13 | .86 | 62 60 | | 400 | 5.50 |
| | | 97 60 | .92 | 581 | 5.5 |
| 4-20 | 1.12 | 58 00 | | 265 | 5.5 |
| | | 155 60 | .98 | 846 | 5.5 |
| 4-27 | .82 | 31 40 | | 200 | 5.27 |
| | | 187 00 | .97 | 1046 | 5.46 |
| 5-4 | .52 | 12 50 | | 148 | 6.16 |
| | | 199 50 | .93 | 1194 | 5.52 |

Ce

| | | | | |
|---|---|---|---|---|
| 4-6 | 44 | .107 | 4 70 | |
| 4-20 | 40 | .11 | 4 40 | |
| | 84 | | 9 10 | .108 |
| 4-27 | 43 | .023 | 1 00 | |
| | 127 | | 10 10 | .08 |

Ce C

| | | | | |
|---|---|---|---|---|
| 3-30 | | | 4 00 | |
| 4-6 | 1848 | .0058 | 10 80 | |
| 5-4 | 2080 | .012 | 24 90 | |
| | 3928 | | 39 70 | .010 |

Cu

| | |
|---|---|
| 4-20 | 4.90 |

| | Cas | Cam. | Cah. | Caw | Car. | Total Ca. |
|---|---|---|---|---|---|---|
| 3-30 | 4.70 | 4.50 | | 4 40 | | 13 60 |
| 4-6 | | 9.20 | 9.20 | | | 18 40 |
| 4-13 | | .20 | 22.10 | | | 22 30 |
| 4-20 | | | 10.40 | | | 10 40 |
| | 4.70 | 13.90 | 41.70 | 4 40 | | 64 70 |
| 4-27 | | | 14.60 | | | 14 60 |
| 5-4 | | 20.10 | 33.40 | | | 87 60 |
| | | | | | 34.10 | 166 90 |

| | | |
|---|---|---|
| | 4/27 | 5/4 |
| a | (⅓) .13 | (¼).19 |
| e | .10 | .10 |
| i | .84 | .81 |
| o | .97 | .93 |
| u | .03 | .02 |
| | 2.07 | 2.05 |

Form. II.

fore, but the divisions are omitted, and it shows only the man's number, his name, hours, rate, and amount. Cards are made up daily, on which the time-keeper notes in symbols what each man does. The time-keeper makes a round of the job and as he finds each man he enters the symbol denoting his work at that time. By making several rounds of the job and by noting the time when important changes are made, such as when concrete starts or stops, when all floor steel is laid, etc., he can get very close to the correct time for each item of work done by each man that day. I say "very close." Absolutely accurate time is practically impossible to record, as the men change so often and unexpectedly that they themselves could hardly tell the exact division for each item of work done. So many timekeepers would be required to keep track of the time in absolute detail that the system would be too expensive to be practical.

On checking his men out at night the time-keeper notes the total hours for each man on the daily card and later transfers the hours to his time-book or checks with the clock-card. The cards are sent to the main office daily.

At the end of the week a payroll sheet is made out and sent in. This, with the cards, gives the office complete information as to the money spent for labor on each item.

### Symbols.

The symbols used are mnemonic in character and divide the work in convenient units for recording. In our original system only the main headings were used, Forms, Concrete, Steel, Finish, Excavation, etc., but after our records showed $1,500 spent on Forms we had little idea of how we stood. When we see $500 making forms, $100 equipment, $100 unloading and $300 erecting we have a very much clearer idea of what the job is costing than before, and a still better idea when our records show the unit cost of each of these items.

In the code the main divisions are capital letters, as "F" for Forms, "C" for Concrete, etc. Each is subdivided into five headings, using vowels a, e, i, o and u. These are used in the order of sequence of work. In general "a" is for equipment, "e" for unloading material, "i" is the first operation and "o" the second operation, with "u" for the final one, as cleaning up rubbish, etc.

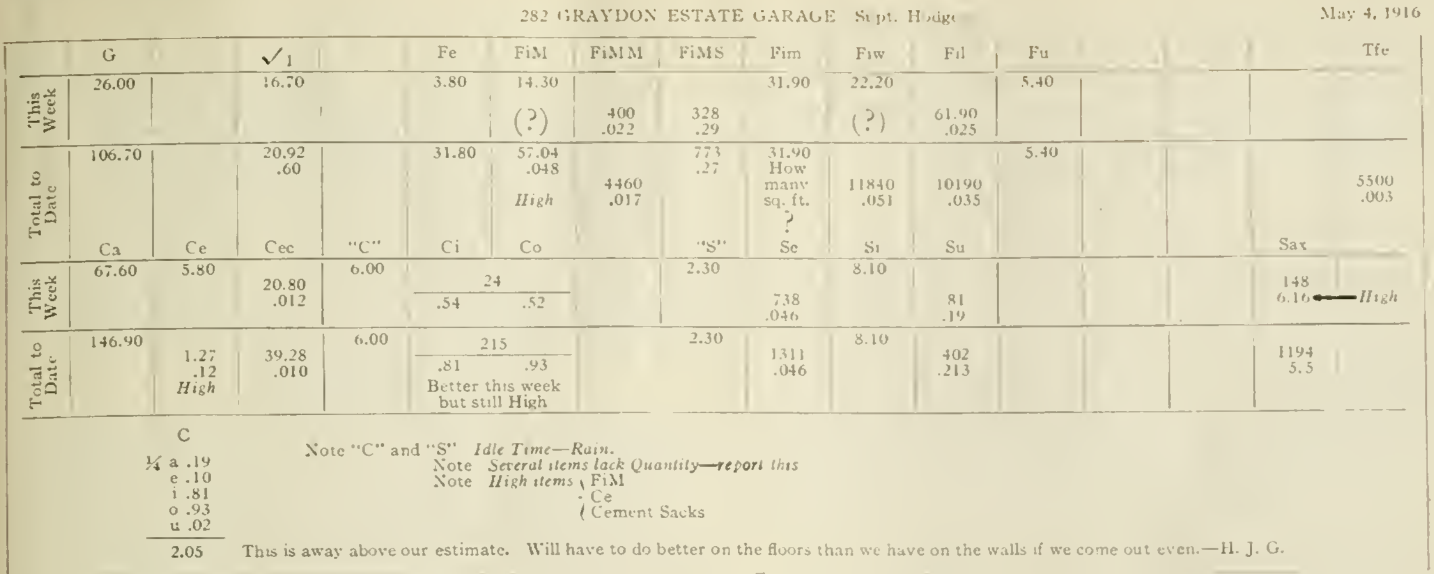
These general classifications apply to every job, and special ones are also used for unusual cases on special work, a list of which are furnished by the office, though the time-keepers are instructed to originate such characters as they require in case of changes or unexpected conditions arising. These are explained on the daily card on which they first occur. Having the cost of work on each of these symbols we need the quantity of work to deduce a unit cost of each item.

### Weekly Report of Work.

At the start of the job the Engineering Department analyzes the estimate, or makes up a new estimate when necessary because of changes in design, and divides the work in such units as will be built separately. This will show the quantity of each class of work in a whole floor if not too large, or in a certain clearly defined section of a floor which is a definite stopping place, in the progress of the work. Form I shows the general scheme followed.

On the close of a week's work the time-keeper notes the status of the work in parts of these units. Thus, "All footings concreted and wrecked; Basement walls, Forms complete, concrete N. & E. sides; Columns, Forms for 10; First Floor, Forms 1/6 complete," etc. With these notes he can go to the schedule of quantities and take off readily the most of these items for his quantity report. Generally he will have to figure some quantities, as Excavation, which is impossible to schedule to advantage, also Cement Finish, Basement floors, sills, etc. These quantities can be taken from the plans or from actual measurements of the work.

Where the job is subject to numerous changes and extras the quantities must be figured on the job and the scheduled quantities used only as a check. This report of quantities is approximate and subject in a certain measure to the time-keeper's judgment. This is impossible to eliminate. If every board be figured in forms actually erected we have still more uncertain quantities. For instance, if forms for 20 columns are standing at the end of the week they may be anywhere from 30 to 80 per cent complete, depending on ledgers, plumbing, clamping, cut-off's, etc. In this instance and in many others, the judgment of the time-keeper or foreman must be used. Suppose the amount of first floor forms be estimated too low. We treat this as an estimate purely until the whole first floor is complete, perhaps a week later, and then we have a complete report on the entire unit. If the estimate shows a tremendously high, or abnormally low cost we call the time-keeper's attention to the fact that his judgment may have erred, and ask him and the foreman to watch the item on the following week.



282 GRAYDON ESTATE GARAGE Supt. Hodge May 4, 1916

| | G | | ✓1 | | Fe | FiM | FiMM | FiMS | Fim | Fiw | Fil | Fu | | | | Tfe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| This Week | 26.00 | | 16.70 | | 3.80 | 14.30<br>(?) | 400<br>.022 | 328<br>.29 | 31.90 | 22.20<br>(?) | 61.90<br>.025 | 5.40 | | | | |
| Total to Date | 106.70 | | 20.92<br>.60 | | 31.80 | 57.04<br>.048<br>*High* | 4460<br>.017 | 773<br>.27 | 31.90<br>How many sq. ft.<br>? | 11840<br>.051 | 10190<br>.035 | 5.40 | | | | 5500<br>.003 |
| | Ca | Ce | Cec | "C" | Ci | Co | | "S" | Sc | Si | Su | | | | Sax | |
| This Week | 67.60 | 5.80 | 20.80<br>.012 | 6.00 | 24<br>.54 | .52 | | 2.30 | 738<br>.046 | 8.10 | 81<br>.19 | | | | 148<br>6.16 ← *High* | |
| Total to Date | 146.90 | 1.27<br>.12<br>*High* | 39.28<br>.010 | 6.00 | 215<br>.81 | .93<br>Better this week but still High | | 2.30 | 1311<br>.046 | 8.10 | 402<br>.213 | | | | 1194<br>5.5 | |

C
¼ a .19
e .10
i .81
o .93
u .02
2.05

Note "C" and "S" *Idle Time—Rain.*
Note *Several items lack Quantity—report this*
Note *High items* { FiM
Ce
Cement Sacks

This is away above our estimate. Will have to do better on the floors than we have on the walls if we come out even.—H. J. G.

Form III.

We therefore get an approximate cost until a unit of floor is complete, and then the cost is accurate within the limits of error, as above discussed.

### Office Work.

As the daily cards come in they are totalled as to money spent for each symbol. The sum of these totals should equal the payroll, and we have set an arbitrary limit of ½ of 1 per cent as an allowable error. We find that the majority of the work comes well within the limits, and careful investigation of errors beyond this limit and a report of same to timekeepers has the effect of keeping them keyed up to the importance of accuracy. The errors are thrown to the item of "G," which stands for "General Expense" and includes regularly time-keeper, watchman, waterboy, etc., as explained on page 6-A. We find errors are not cumulative, but generally offset each other very closely.

Record of the labor on each job is kept in separate folders on loose leaf sheets 8½x11 in., ruled in three general columns. In these columns we enter under the proper symbols the date and amount spent each week on that item, and bring down a total to date in red ink. The amount of work done is also entered, and a unit cost for the week figured. Then from the total work to date and the total cost the total unit cost to date is figured. (See Form II.)

The total costs of the three main divisions of our work (concrete, forms and steel) are obtained each week by summing up these various units in their proper relation. This requires care and the exercise of good judgment in weighing the miscellaneous items. For instance, equipment and perhaps unloading costs come in at the very start before any actual work is erected. The cleaning up items may come in only after considerable work has been done. In the former case our practice is to estimate a unit for a few weeks, then use a fractional part of the equipment cost, and in case of forms a fractional part of the unloading also. We use an estimated figure of what the cleaning up item will likely amount to until it begins to come in regularly enough to actually figure. Such estimates are always indicated by an abbreviation "Est.," or by the fractional part used, as "⅓."

### Weekly Labor Summary.

A report of these weekly unit costs and the total unit costs is made up each week. It also shows the totaling of the main divisions, comparing same with the previous work, or with the estimate. Notes and comments are freely used, and unusual items underscored in red ink for special attention. These are made out in the same symbols as the time-keeper's code, so that the uninitiated would not be able to decipher it intelligently. The amount of cement used per yard and any other material items which may have been specially checked will appear on this report also. One copy goes direct to the superintendent on the job, another to the officers of the company for inspection. These reports are referred to in the weekly executive meeting, in which all current work is checked up as to time, delays, cost of work, etc. A sample of this report is shown by Form III.

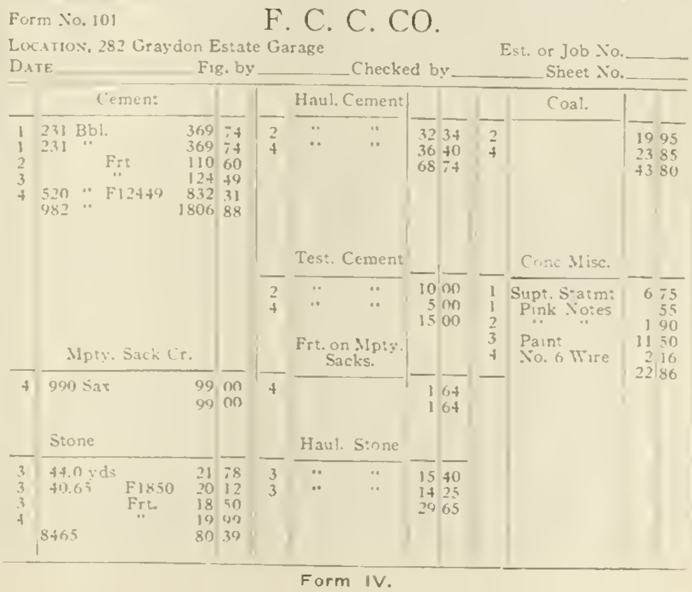
### Curves.

On large jobs we have found it advantageous to use curves to show the weekly fluctuation of the main items of labor. The estimated labor cost is a straight line; when the curve goes above this line we are losing money, when below we save over our estimate. These have proven very satisfactory, but are only used on large jobs where the work extends over several months. The small jobs are complete before the items of equipment, unloading, etc., can be properly proportioned.

### Recording Materials.

The daily report shows the receipts of all items at the work. It is made out and sent to the main office daily by the time-keeper. The name of dealer, quantity and description is given, also price, if this has been left to the job to buy. On receipt of these daily reports at the main office the dealers' bills are O.K.'d by the purchasing department. These bills then go to the cost department for entry; this entry must be made promptly to avoid delay in payment and a possible loss of discount. Hence they are entered at once in a loose-leaf ledger by jobs, showing the dealer's name, quantity, description, price, gross bill, freight deductions, and net bill. The bill is initialed and passed along to the bookkeeper for further record and payment. Periodically the cost ledger and the bookkeeper's ledger are balanced, and any errors or omissions corrected.

From this cost ledger the items are transferred to the folder records for each job and each entry is classified under its proper heading or headings. Thus, cement



Form No. 101
F. C. C. CO.
LOCATION, 282 Graydon Estate Garage Est. or Job No.______
DATE ____________ Fig. by __________ Checked by __________ Sheet No.______

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cement | | | | Haul. Cement | | | | Coal. | | |
| 1 | 231 Bbl. | 369 | 74 | 2 | " " | 32 | 34 | 2 | | 19 | 95 |
| 1 | 231 " | 369 | 74 | 4 | " " | 36 | 40 | 4 | | 23 | 85 |
| 2 | Frt | 110 | 60 | | | 68 | 74 | | | 43 | 80 |
| 3 | " | 124 | 49 | | | | | | | | |
| 4 | 520 " F12449 | 832 | 31 | | | | | | | | |
| | 982 " | 1806 | 88 | | | | | | | | |
| | | | | | Test. Cement | | | | Conc Misc. | | |
| | | | | 2 | " " | 10 | 00 | 1 | Supt. Statmt | 6 | 75 |
| | | | | 4 | " " | 5 | 00 | 1 | Pink Notes | | 55 |
| | | | | | | 15 | 00 | 2 | " " | 1 | 90 |
| | | | | | Frt. on Mpty. Sacks. | | | 3 | Paint | 11 | 50 |
| | Mpty. Sack Cr. | | | | | | | 4 | No. 6 Wire | 2 | 16 |
| | | | | | | | | | | 22 | 86 |
| 4 | 990 Sax | 99 | 00 | 4 | | 1 | 64 | | | | |
| | | 99 | 00 | | | 1 | 64 | | | | |
| | Stone | | | | Haul. Stone | | | | | | |
| 3 | 44.0 yds | 21 | 78 | 3 | " " | 15 | 40 | | | | |
| 3 | 40.65 F1850 | 20 | 12 | 3 | " " | 14 | 25 | | | | |
| 3 | Frt. | 18 | 50 | | | 29 | 65 | | | | |
| 4 | " | 19 | 99 | | | | | | | | |
| | 8465 | 80 | 39 | | | | | | | | |

Form IV.

bought and the freight is in one column, the hauling in another; freight on empty sacks, credits for empty sacks, testing, etc., are separate items on each job. The amount and cost of each material is thus readily available for comparison with the estimate, or for figuring costs. See Form IV for a sample of this sheet.

### Analysis of Estimate.

As made up for bidding, an estimate rarely is divided so that the amounts of either labor or exact materials are available without further analysis. This analysis is made by the cost department soon after the contract is signed, and shows the labor items by symbols divided as the work will be done, giving estimated quantity and estimated unit cost. The materials are totaled and include hauling, miscellaneous expense, etc., all listed separately in such separate headings as are found by experience to be most advantageous. Both of these, but more especially the labor, may vary from the actual estimate, and be based on what experience indicates the work should be done for. Hence, if mistakes be made in the original estimate the job is still placed on its merits.

The net variance from the estimate when a saving is carried as a contingency item to care for unexpected conditions, delays, etc. This analysis may be carried into too little or too great detail until the most advantageous divisions are found. They soon develop into a standard form, so that this question is not long a troublesome one.

### Bi-Monthly Status.

A comparison of actual results and those previously estimated is now possible, and a sheet is prepared approximately every two months, showing what each item of labor was expected to cost, both in units and total, and what it has cost. The total saving or the loss is figured and entered for each item, or group of items. This brings in all materials and all the labor, so a total net saving or net loss gives the true status of the job on that date.

In making this comparison allowance must be made for materials on hand for future work, and requires a fairly accurate knowledge of the job conditions at the time. This statement goes to the job superintendent and also to the officers of the company for inspection and criticisms. Its totals show whether the job is making or losing money, and by looking through the items the source of the profit or loss may be determined.

### Final Analysis.

At the close of a job, after all claims and delayed bills are adjusted, the cost of each item in the estimate is figured in more detail. The bi-monthly statements do not show what part of the concrete materials bought have been used in the basement floor, for instance. Materials for such items are separated from the concrete work, priced and entered as the material cost on these items, from which the unit material cost is figured. Likewise, a proportionate part of the labor on equipment, unloading, and cleaning up, is added to the direct labor cost. We now have a total labor and total material charge on each item of the original estimate and by comparing the estimate with the actual cost we can find the profit or loss on each more definitely than in the bi-monthly reports.

These final analyses are entered in the permanent cost record in detailed form for future reference. On this record sheet we also figure the actual cost per square foot of floor of the concrete only, and then of the various subcontract branches. A short description of the job, the prices of main materials and labor, and notes regarding job conditions make this a valuable record for later reference.

### Personal.

This system of recording costs, as now operated, requires no additional men on the jobs. It does require some ability in reading plans on the part of the timekeepers, which has brought us to favor young engineers for such work. Should they show executive ability training in timekeeping makes them the more valuable to us as foremen or superintendents.

The office work at present requires the full time of two men. Their reports are inspected and supervised by the writer, who takes up any unusual items with the superintendent and the office. Our plan has been to go to the job and carefully investigate the high costs and we are working with that end in view, although a great deal must be left to the superintendent. He is in a better position to go into the details of high cost items than we from the office. If he be interested in his cost reports and co-operates with us to secure promptness and accuracy on the part of the timekeeper our work is much simplified. We are glad to receive the superintendent's criticisms of the reports, as they show that he is interested and is watching them closely.

## PERSONALS.

Robert Caldwell has been appointed city engineer of Richland Center, Wis.

H. S. Riddle has resigned his position as chief consulting engineer of the State Board of Administration of Ohio.

M. F. Northam, office engineer of the Southern Railway at Washington, D. C., has been appointed supervising engineer.

T. R. Ratliff has been appointed engineer maintenance of way of the Indianapolis Union Railway, with office at Indianapolis, Ind.

F. B. Tapley has been appointed an assistant engineer of the Canadian Government Railways with headquarters at Moncton, N. B.

Charles M. Edwards, heretofore resident engineer of the New York State Highway Department, has been promoted to the position of division engineer.

C. D. Peacock, for the past four years city engineer of Brainerd, Minn., has resigned, and Louis Knudson of Brainerd has been appointed to succeed him.

James H. Ellison of the firm of Winston Bros., railroad contractors, Minneapolis, and M. F. Nichols of Thompson Falls, Mont., have purchased the Thompson Falls Water Works Co.

Frank J. Engel and Herman F. Hevenor have organized the firm of Engel & Hevenor and will engage in an engineering and contracting business with offices at 220 Broadway, New York.

Lieut.-Col. J. W. Stewart, a well known railroad contractor of Canada, is now with the 239th Railway Construction Corps with headquarters at Valcartier, Canada. This corps is being organized for the building of railroads for the conveyance of ammunition, guns and hospital supplies in the European war zone. Each company will consist of four blacksmiths, three fitters, twenty-five bridgemen and carpenters, four enginemen and 159 tracklayers and teamsters, with cooks, tailor and shoemaker. Lieut.-Col. Stewart was president of the Pacific Great Eastern Railway, which is building a connecting link with the Grand Trunk Pacific into Vancouver, B. C. All the officers of the corps have been especially chosen for their experience in railroad construction.

Clarence D. Pollock, member Am. Soc. C. E., consulting engineer, with offices in the Park Row building, New York City, and George A. Taber, member Am. Soc. C. E., consulting engineer, who has been associated for the past three years with the offices of Nicholas S. Hill, Jr., and S. F. Ferguson, New York City, have formed a partnership under the name of Pollock & Taber for the purpose of extending the consulting practice of Mr. Pollock into broader fields. The firm will specialize in pavements, water supply, sewerage and sewage disposal for private concerns and municipalities. Mr. Pollock has had over twenty years of practical experience, having had charge of the paving of New York, Brooklyn, Havana, Cuba, and San Antonio, Texas. He also had a varied experience in sewerage construction and drainage and as an expert in litigation. Mr. Taber has been engaged in water supply engineering for over fifteen years. He has successfully been in charge of the designing, maintenance and construction work of the Department of Water Supply in various boroughs of New York City for three years and was engineer-in-charge of the main office of the Croton Aqueduct Commission, during which time several large masonry dams on the Croton watershed were constructed. He also has had extensive experience in connection with the development of water power, fire protection, street cleaning and sewage disposal, and in the valuation of private water companies for municipal and state purchase. Mr. Taber will retain his connection with the Polytechnic Institute of Brooklyn as consulting professor of water supply and sewage disposal. The new firm will have its offices in the Park Row building, New York City.

## OBITUARY.

Hugh Murphy, a well known paving contractor of Omaha, Nebr., died recently at Old Orchard, Me., after a lingering illness. He was 64 years old and had lived in Omaha since 1878.

Robert I. Pierson of Sunnysouth, Ala., superintendent of the Hardway Company, in the construction of a bridge over the Catawba River near Nitrolee, S. C., was killed last week by negro laborers in endeavoring to stop a disturbance in the camp.

## NEW CATALOGS.

**Filing Cabinet.**—Paper; 5 in. x 7¾ in.; 16 pp. Yawman & Erbe Mfg. Co., Rochester, N. Y.

The cabinet described in this catalog has been designed for the filing of drawings, sketches, blue prints, etc. It is of the vertical type and it is especially adapted to the needs of architects, draftsmen, engineers and contractors.

**Microscopes.**—Paper; 5½ in. x 9¾ in.; 142 pp. Bausch & Lomb Optical Co., Rochester, N. Y.

This is the twenty-fourth edition of the microscope catalog of the company. It contains illustrations and descriptions of the complete line of goods made by this firm. The company's new apochromatic objectives are listed in this catalog. This complete series of true apochromatics is the first to be offered by an American manufacturer.

**Engineering Instruments.**—Paper; 10 in. x 12 in. C. L. Berger & Sons, 41 William St., Boston, Mass.

Five bulletins, as follows, have been issued by this concern describing the various types of Berger transits and levels: No. 1, Monitor type Wye and dumpy levels; No. 2, engineers' and surveyors' transit; No. 3, Monitor transit; No. 4, transits; No. 5, 5½-inch Monitor transit. Full descriptions of each of these instruments and illustrations of the complete instrument and its parts are given. Several of the bulletins contain views of notable construction works on which these instruments were used.

Roads and Streets Issue
of
Engineering and Contracting
Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., SEPTEMBER 6, 1916. Number 10.

## ABSENCE OF "PORK BARREL" METHODS IN THE FEDERAL-AID ROAD LAW.

A few daily papers have commented unfavorably upon the recently enacted federal road law. Generally these adverse comments come from editors not well acquainted with the provisions of the law. Accordingly, it will be wise for civil engineers to write to the editors of periodicals in which criticism of the law appears.

The editor of Engineering and Contracting recently wrote a letter to the editor of the Public Ledger of Philadelphia. The letter was printed in the Ledger, and we reprint it here:

"Sir: I was sorry to see in your editorial columns this morning reference to the federal road aid appropriation as one to be classed among the 'pork barrel' bills.

"Whether federal aid in road building shall become a messmate with the rivers and harbors bills is, of course, a matter of concern to all who want to see wise expenditure of public funds. The road bill just passed by Congress was carefully drawn to prevent 'pork barrel' methods of distribution of public funds. It provides that for every dollar supplied from the treasury of Uncle Sam another dollar must be matched against it by the state that profits from the building of roads with federal money. No such provision as this has ever guarded the government's expenditures for rivers, harbors and post offices.

"You may, of course, question the economic wisdom of national aid in road building, but that is another matter. I know that many editors likewise questioned state aid in road building when it was first proposed, about 20 years ago. All opposition to state aid was grounded on the same reasoning as the present opposition to federal aid. Roads were declared to be like city streets, merely local structures that could be built and maintained with local funds. Who is there now who objects to state aid in road building? State highway commissioners have proved both their efficacy and, with rare exceptions, their honesty. What the farmer would not, or could not, do unaided by residents of cities is at last being done, at least in a measure. Good roads are beginning to be built in all parts of America, and very largely as the direct results of state aid.

"But a vast deal remains to be done. I estimate that all the country roads in America can be reproduced for less than $3,000,000,000, whereas it would take more than $20,000,000,000 to reproduce all the railways. There are 10 miles of road to every mile of railway, and more farm produce is hauled over the roads than over the railways. The investment in roads should fully equal the investment in railways if a well-balanced plant for use in hauling agricultural produce is to be secured.

"The cost of the 2,500,000 automobiles in America is almost as great as the cost of reproducing all the roads. The cost of the railways, on the other hand, is about six times the cost of the engines and cars. Some such ratio of investment—six to one—between roads and automobiles will eventually be secured, but we are a long, long way from the desired Tipperary.

"If roads are of more than county or township value—and everyone concedes now that they are—it is equally certain that they are of more than state value. Take, for instance, the main road from here to Boston. It is as truly an interstate highway as the railway it parallels. Along the Texas frontier there are no roads worthy the name of highway, and there never will be if Texas is left to build them unaided. Yet for military purposes alone a system of national highways should be built in all the states that border Mexico. And, if this is true there, it is perhaps even more important that all our frontiers be supplied with federal highways for military purposes in time of war and for commercial and pleasure use in times of peace.

"The use of auto trucks has again brought the military road to the fore as one of the most essential parts of any system for national defense. Not since the days of the Romans have roads for purely military purposes been so well justified as they now are. Fortunately, a military road is not like a fort or a gun, useless save for military purposes.

"But, entirely aside from use for military or postal service purposes, I believe that the federal government should lend financial aid to the states in building roads. There is in the aggregate a vast general profit to be derived from good roads, a profit that cannot be recovered by those who live along or near the roads. Since this general profit accrues to the benefit of every citizen, it devolves upon the entire nation to share in the cost that makes the profit possible."

## THE "MUNICIPAL IMPROVEMENTS" CONVENTION IN OCTOBER.

The American Society of Municipal Improvements holds its annual convention Oct. 9 to 13 at Newark, N. J.

This society, although 23 years old, has membership in only 235 cities. The secretary, Mr. Charles C. Brown, in conducting a vigorous campaign to increase the membership, states that there are 3,500 cities that should be represented by membership.

May we suggest that the society would be apt to show more rapid growth were its interests confined to those of the city engineer? Has the society not spread its butter too thin in past years?

The average city engineer has little to do with the lighting of city streets, for example. Hence papers on street lighting interest him very little. For similar reason, he is little interested in discussions of fire protection problems, as a rule. By excluding these and other problems that lie beyond the province of the average city engineer, and by confining its discussions to the common problems of the city engineer, we believe that this society will grow more rapidly than in the past.

The convention at Newark is one that city engineers will do well to attend.

## TRACTIVE RESISTANCE TESTS WITH AN ELECTRIC MOTOR TRUCK.

By the measurement of electricity consumed in propelling electric motor trucks it is now possible readily to secure data as to tractive resistances at various speeds and under different conditions. At a recent meeting of New England electrical men in Boston, Prof. Dugald C. Jackson outlined the results of some tests made by Messrs. Kennelly and Schurig of the research division of the Massachusetts Institute of Technology. Details of the tests are to be published by the Institute in about three months, but the following summaries, as given by the Electrical World, will prove significant of certain facts that have hitherto received scant consideration:

The truck was a half-ton electric delivery wagon equipped with solid tires, roller bearings, and worm drive. Running at 15 miles an hour on tar-macadam, the power was consumed as follows:

| | Per cent. |
|---|---|
| Rolling, axle and impact resistance | 60 |
| Air resistance | 10 |
| Total tractive resistance | 70 |
| Motor and control system | 20 |
| Transmission friction | 10 |
| Total per cent | 100 |

Eliminating the effect of air resistance, the tractive resistances per ton of 2,000 lb. over different kinds of pavement, at speeds of 10 to 15 miles per hour, were about as follows:

| | |
|---|---|
| Asphalt pavement | 17 |
| Wood block | 17 |
| Brick pavement | 20 |
| Tar macadam and macadam | 20 |
| Granite block, cement joints | 27 |
| Granite block, gravel joints | 42 |
| Gravel roads | 24 |

The above are all for pavements in good condition, and exclusive of the air resistance of the truck, which added about 5 lb. per ton tractive resistance at 12 miles per hour. The air resistance increases as the square of the velocity, but no tests were reported as having been made on this resistance at different speeds.

Macadam badly rutted showed a 50 per cent increase in resistance. Cinder roads showed about the same resistance as gravel roads. With granite pavement the resistance rises rapidly with the speed, due to impact resistance.

Similar tests published three years ago confirm these, and show that an asphalt pavement covered with hard snow shows a 33 per cent increase in resistance, and if the snow is heavy and soft the increase in resistance is 100 per cent.

## A MUNICIPAL ASPHALT MIXING PLANT THAT SELLS "HOT STUFF" TO CONTRACTORS.

Spokane, Wash., owns an asphalt mixing plant that has been operated for six years with apparent success. With asphalt at $16 a ton, the city itself has laid a large amount of 2-in. "asphaltic concrete" at a cost not much in excess of 37 ct. per sq. yd. in place on the street, exclusive of interest, repairs, depreciation and overhead expenses.

The city has also sold the asphaltic concrete mixture, or "hot stuff," at its plant to paving contractors. It is to this practice that we particularly call attention. Contractors are thus relieved of making a comparatively heavy investment in an asphalt mixing plant. Their function, then, is to mix and place the concrete base, and to haul, spread and roll the asphaltic top.

It is claimed that this combination of contract work and city day labor has resulted in a substantial reduction in the cost of asphalt pavements in Spokane.

The labor cost of handling and mixing the materials at the municipal plant has been less than 4 ct. per sq. yd. of 2-in. asphaltic concrete, so it is evident that the usual inefficiency of laborers working for a city is not evident here. But even if there were considerable inefficiency it would not cause much concern where the labor cost is a small per cent of the total cost.

## INFANTILE PARALYSIS, DUSTY STREETS AND THE AUTOMOBILE.

Never has any city experienced such an epidemic of infantile paralysis as that that has afflicted New York this summer. Never in the memory of the editor have the streets of New York been so generally dusty as this summer, and never have there been so many effective devices for stirring up the dust. May it not be more than a coincidence that these three conditions are conjoined—infantile paralysis, dusty streets and automobiles?

Whether the paralysis germ is blown about or not is open to question, but the evidence seems to indicate that it travels through the air. Note, for example, the decrease in the disease following the recent showers.

Infantile paralysis disappears almost entirely in the autumn, and this has been attributed to the fact that its germs are carried by flies or other insects. But flies and insects seem to have remained quite as active as ever, although the number of new paralysis cases has decreased.

Many diseases, such as tuberculosis and "colds," are known to be transmitted on or with dust that is inhaled. Infantile paralysis seems to be carried in a similar manner. In any case, the lesson is apparent: Cities must have cleaner streets.

The rapidly moving automobile has greatly increased the dust nuisance, and, as the number of motor cars is increasing in geometric ratio, the inference is plain that a formidable problem confronts all cities. Before there can be really clean streets there must be more pavements that can be readily cleaned. The old cobble pavements obviously must go, and the old waterbound macadam pavements either must go or must be resurfaced with some bituminous compound. In fact, every type of pavement that has become worn or pounded into humps and hollows must give way to a smooth, clean pavement.

We believe that, with the general advent of smooth, non-porous pavements, street flushing will be universally demanded as a matter of sanitation.

## SHOULD STONE BLOCK PAVEMENTS BE LONGER TOLERATED?

It has long been known that tractive resistance on rough roads increases very rapidly with increased velocity. The recent tractive tests with a motor truck, reviewed elsewhere in this issue, simply confirm a well-known fact, but they are strikingly significant. It will be seen that even at as low a speed as 12 miles an hour a granite block pavement with gravel or sand joints, but laid on a concrete base, shows two and a half times the tractive resistance of asphalt. Even a very smooth granite pavement with cement joints shows a resistance 60 per cent more than asphalt at 12 miles an hour.

At higher speeds—20 miles an hour or more—granite blocks will be found to be much more resistant to traction. This is inevitable, for the best of springs cannot entirely overcome the vertically propulsive effect that a load experiences when handled rapidly over irregularities in a road.

Tractive resistance is a composite resistance, and its elements are: (1) Axle resistance, (2) rolling or "roller" resistance, (3) impact resistance, and (4) air resistance. The last two increase rapidly with increased velocity. Air resistance increases as the square of the velocity; double the velocity and you quadruple the air friction. Impact resistance results from the power consumed in overcoming the inertia of the load when raising it vertically over irregularities in the road. This also increases rapidly with increased velocity, but its rate of increase is dependent on several factors, among which are the springs and the tires. Steel springs of design suitable to the load, and rubber tires, particularly pneumatic, serve materially to reduce the impact resistance of vehicles. The editor has made considerable study of the spring problem, and in the next Roads and Streets Monthly issue, Oct. 4, will present some results of his study.

Stone block pavements are so expensive in first cost that their economic use has never been justified at all, except where traffic is very dense. We go further and say that granite block pavement is never economic where the traffic is principally that of motor vehicles having rubber tires, even where the traffic is the most dense in the world. Rubber tires have vastly lessened the wear on all pavements, save waterbound macadam. This is so conspicuously evident that it seems to need no confirmatory records or tests. Nevertheless we suggest that city engineers, many of whom have been accustomed to rely upon experience with iron tires, will do well to gather new data as to pavement wear under rubber-tired vehicles.

Would it not be well also to run a loaded motor truck continuously, night and day, for several months over a granite pavement, and coincidentally run another similar truck over an asphalt pavement? Measurements of wear and tear on the two trucks would yield a quantitative answer as to the cost of vehicular upkeep on the two types of pavement. City engineers have been inclined completely to ignore this very important factor in the economic design of a pavement for modern conditions.

## EDITORIAL COMMENT.

A 30-mile gravel road was built last year in Maine, to serve as a construction road over which to haul cement and steel for a dam for the Great Northern Paper Co. Mr. H. S. Ferguson of New York, consulting engineer for the company, estimates that by the use of motor trucks (nine 5-ton white trucks) the cost of hauling about 20,000 tons of cement will be half the cost that team haulage would have caused. The road is dragged after every rain and is constantly maintained in good condition.

The first brick pavement in which the brick were laid flatwise is said to have been laid in Greenville, Texas. The idea of laying paving brick flatwise was first published by the editor of Engineering and Contracting 15 years ago. Ten years ago (Sept. 26, 1906) Engineering and Contracting described the laying of an asphalt block pavement in New York City where the blocks were laid flatwise, and in the same article was described the use of a mortar bed instead of a "sand cushion." In Kansas City, Mo., 16,000 sq. yd. of thin (3-in.) brick paving blocks were laid on a concrete base in 1914. Thin brick pavements seem likely to increase rapidly in popularity.

Swarthmore College has introduced "public speaking" as part of its engineering course. Shop accounting has also been introduced, and in a very practical manner. The students, among other things, are required to "ring in" on a time clock when they enter and leave classes. This is a step toward answering a question that Engineering and Contracting first propounded years ago: Why not run an engineering college as if it were an industrial organization?

## COMPARATIVE COSTS OF PAVEMENTS.

To the Editors: Your editorial comment and that of one of your correspondents on the above subject in your Aug. 2 issue drew my attention to the proceedings of the National Conference on Concrete Road Building, from which the data referred to were quoted.

The author leaves it to be inferred from his conclusions that the figures he has given are largely assumptions for the purpose of bringing out discussion, and analysis of his table shows that such must have been the case. While agreement must be expressed with the comments made by your correspondent, as well as with those in your editorial, on the failure of the author to establish a common basis of comparison, I think that attention has not been drawn to a fallacy even more fundamental and one which is frequently encountered in discussions on subjects where the data are incomplete, namely, the use of mathematics and graphical diagrams in a manner indicating a degree of precision much more accurate than the premises warrant. One of the first cautions given to engineering students is to avoid tedious processes whereby results are indicated to ten places of decimals when the quantities from which the results are derived are not known accurately even to the nearest place of units. Such methods persist in the work of young engineers long after college days, but they are not supposed to be adhered to after the arrival at years of discretion and responsibility, and it is, therefore, very surprising to encounter tabulations in which values of pavements are carried out to hundredths of cents, based on assumptions as to the present cost of pavements which cannot have even an approximate accuracy within a variation of 10 ct. per yard and where the assumed life must have a probable error of at least 50 per cent. To the reader inexperienced in highway work, the article would carry a very reasonable presumption that the values of the pavements shown in the graphical diagram were derived from precise data, since this diagram and the accompanying tables from which it is derived are being used for advertising purposes by the advocates of certain types of road, who give to them the implied weight of authority of the New York Bureau of Highways. It is very possible that the inaccurate impression will be spread in many quarters that these conclusions represent the results of a careful study of data in the records of New York City and embody conclusions authorized by results on a large proportion of the streets and roads in its vicinity.

Without question, such conclusions were far from the author's intent, which was, as he stated, to bring out discussion. It is unfortunate that he failed to state in his paper the derivation of his basic assumptions and other limitations restricting his comparative figures.

It should be noted that these unit costs are not taken from New York City records, neither does he state his authorities, nor as to what extent cost of suburban roads about New York City was used in obtaining the average costs employed. He certainly does not appear to have taken into consideration the northern portion of the state of New Jersey in studying "the country district immediately about New York City."

As you say, there are no data justifying the estimate of 20 years as the minimum life for pavements in this region. On the contrary, data show that such is not the case for most pavements in existence at the present time.

For example, the author has included among his types compared, sheet asphalt, constructed in accordance with Borough of Manhattan specifications. As these specifications are peculiar to that borough, it is fair to check him by its records. A careful study made a short time ago of the records of all asphalt pavements in Manhattan showed that their average life was a little over 14 years; the study also showed that these figures varied very slightly under various intensities of traffic.

The author also assumes the cost of these pavements, exclusive of foundation, at 90 ct. per square yard, a figure which is much below the average price at which sheet asphalt pavement has been laid by the Borough of Manhattan in recent years. It is doubtful whether there is any pavement in the borough of any considerable extent which has lasted 20 years at an annual repair cost of 2 ct. per square yard.

The figures assumed for concrete pavement seem to be derived from the general averages reported to the committee of the National Conference wor work throughout the country. They are certainly not obtained by averaging all the concrete roads in the vicinity of New York of which the number is limited and of which a small portion is under my present jurisdiction, while none has ever been constructed in the Borough of Manhattan. Bituminous macadam and waterbound macadam are such vague terms and describe such varying types of construction, that an average cost can have but very little meaning, and when figures on wood and granite block are introduced, it merely emphasizes your claim as to the comparison of incomparables.

These are two types of pavement which are admittedly expensive and are used for reasons other than that of immediate economy in first cost.

The question of whether or not the various classes of pavement compared have been reduced to a common basis as regards foundation seems to me immaterial, for admitting some lack of precision in this regard, it still remains much less liable to be erroneous than are the original assumptions; for even though the author appears to have treated his concrete pavement much more kindly in his assumptions as to its value as a future foundation at the end of its useful life, his basic assumption that that life will be 20 years is so much more of a wild guess as to eliminate immediately all possibility of comparing results.

Very little purpose is served by the publication of a solemn discussion as to what would be the results under certain conditions, every one of which is assumed, and in no case based on any known data. Such data as exist, and particularly those in the records of the Bureau of Highways in the Borough of Manhattan during the years that I had charge of those streets, including the comparative records of the mile of test pavements constructed on Second Ave. in 1812, do not agree in any respect with the figures shown.

It seems to the writer that the vague generalities and harmless platitudes found in many road discussions are on the whole less liable to lead others into error than are discussions which use the machinery of a scientific treatise, without the raw material of facts necessary to be supplied in order that we may turn out a finished product of definite conclusions.

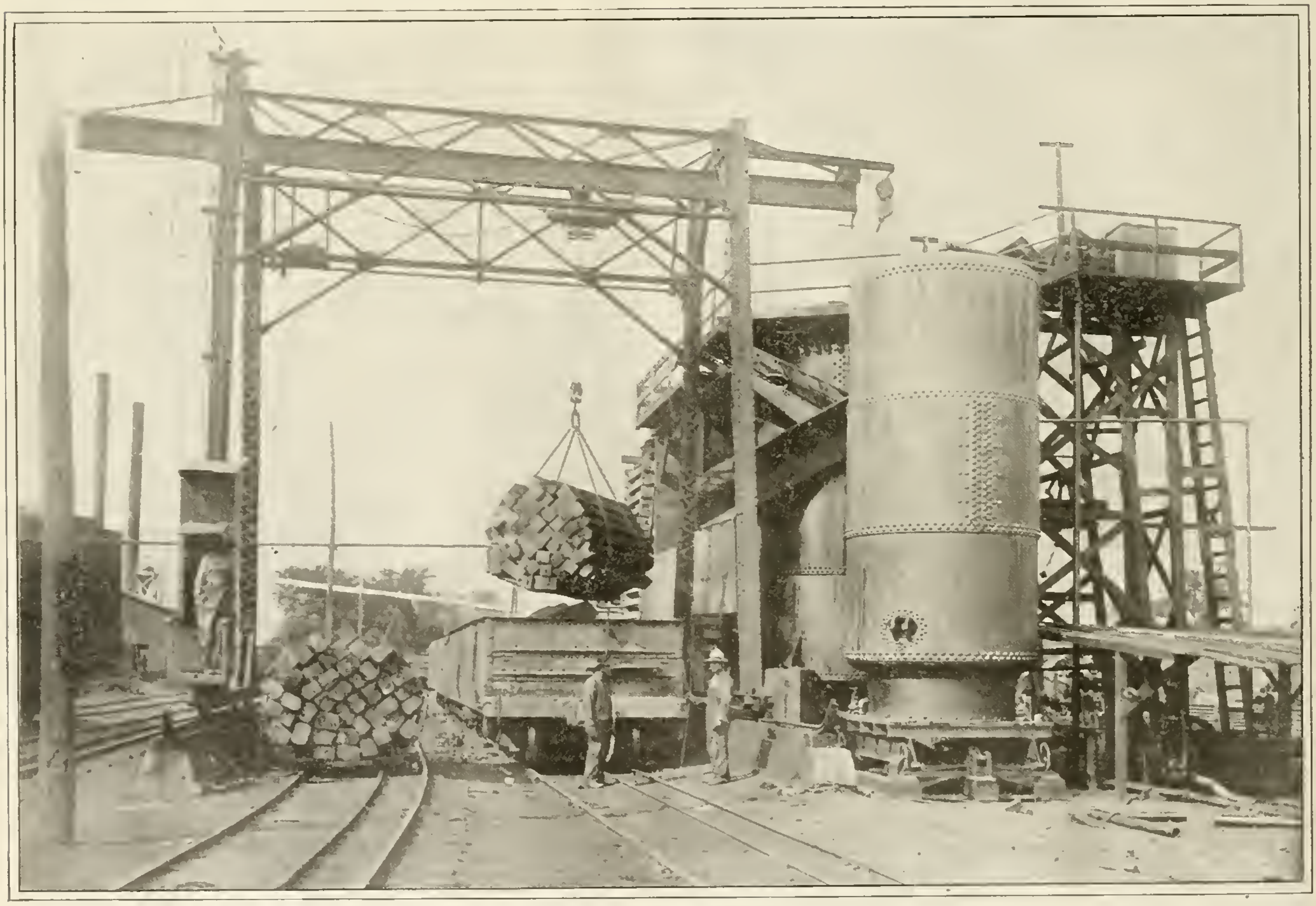
Yours very truly,
Henry Welles Durham.
Hackensack, N. J., Aug. 14, 1916.

## CREOSOTING WOOD BLOCKS IN VERTICAL TANKS.

Contributed by W. F. Schaphorst, New York, City

Vertical creosoting tanks for treating wood blocks for pavements is a comparatively new departure. These same tanks can be used for treating railway crossties, as is indicated by one of the views. The particular plant shown is at Orrville, Ohio, where the Shipley process of creosoting is used. The cylinders are made in two sizes, one designed for containing 300 yd. of paving blocks and the other for 200 yd. Each is fitted on the inside with a hydraulic plunger and platform, so that when empty and about to be charged with wood blocks, the platform is at the top. As the blocks are delivered into the tank, the platform lowers gradually, thus preventing breakage. When the cylinder is full, the cover is put on and the usual treatment administered. Then the cover is taken off and the plunger started upward, the blocks falling off into a chute which leads directly into cars for shipment.

The chief advantage of the vertical tank, from the standpoint of the wood-block labor industry, is its simplicity of operation and the low first cost. These tanks are easily transported and at a freight cost far less than that of the heavy horizontal-cylinder equipment.



View of Vertical Tank Creosoting Plant at Orrville, O.

## THE DAVIS SPOT TEST IN THE PRELIMINARY EXAMINATION OF CREOSOTE OILS.

The presence of tar, free carbon or dirt in creosote oil is indicated in very minute quantities in the preliminary examination by the use of the Davis spot test. This test, while very simple, has proved certain and unfailing. It is as follows:

Allow six drops of a sample of creosote oil to fall upon the surface of clean, white blotting paper. If tar, free carbon or dirt is present it will be readily observed, as it quickly segregates at the center. The paper should be laid away in a flat position for a few hours in a place where there is no dust. If then examined, foreign matter will be observed in a distinct zone in the center of the spot, the outer zone very readily indicating the character of the oil.

The various types of wood-preserving oils can be easily distinguished from each other by this test when they are true samples.

In order to determine the sensitiveness of the spot or discoloration test and to make it fairly quantitative, a series of spots was made by the Forest Products Laboratory at Madison, Wis., from a carbon-free creosote oil to which carbon in the form of lampblack had been added in graduated amounts. The results obtained disclosed an increasing gradation of the free carbon at the center and indicated that 0.005 per cent is easily shown by this test. In percentages heavier than 0.5 per cent the amount in an unknown sample would be difficult to estimate by comparison.

The efficacy and reliability of the Davis spot test would seem to have been fully demonstrated after six years' use in the examination of creosote oils and by its adoption by the Diesel Engine Users' Association of England for testing the purity of the oils used for fuel in this type of engine.

In 1915 the city of St. Paul, Minn., adopted the spot test for the examination of the creosote oil specified for its wooden block streets. The specifications called for pure, high-gravity distillate oil, and as a safeguard of this purity the Davis spot test was made a part of the specifications. It appears that the St. Paul wooden block pavements, although but 12 pounds of oil to the cubic foot of timber were used, have given complete satisfaction. On account of the large proportion of high-boiling fractions in the oil and the absence of low-boiling tar oils, which are readily affected by the sun's rays, "bleeding" of the blocks has been practically eliminated.

At a recent meeting of the city council of St. Paul, at which were present the professors of chemistry from the University of Minnesota, it was voted to make no change in the creosote oil specifications and to retain the spot test, which action was suggested by the professors, who approved the spot test as a simple and effective means of detecting any adulteration of the creosote with filtered tar, the most prevalent form of adulteration.

## RECOMMENDATIONS FOR A MODEL STREET CLEANING DISTRICT.

Interesting recommendations regarding the installation of a model street cleaning district by the Department of Street Cleaning of New York City are given in a recent report of Richard T. Fox of Chicago, Ill. The primary object of the model district, which originated with Mr. John T. Fetherstone, Commissioner of Street Cleaning of New York City, is to furnish a small area representing the different types of street conditions found throughout the city, in which to install the most up-to-date method of work and equipment that can be obtained, and gradually to extend the system to cover the entire city. The secondary purpose is to provide a proving ground for new developments, from time to time, in methods of work and equipment before final adoption.

Mr. Fox's recommendation affecting the installation of the model district were as follows:

1. That hand cleaning only be employed, supplemented by flushing or washing with water under pressure.

2. That the intensive method of street cleaning be adopted.

3. That the value of inspection cannot be over-emphasized in any attempt to maintain high standards of street cleaning, and therefore the supervisory force be composed of A No. 1 men, intelligent, industrious and observing. That the laborers be alert and active and capable of maintaining the standards of work set.

4. That leggins be added to the uniform now used, to protect the trousers and to add completeness to the equipment.

An order requiring the men to polish their shoes daily is of great value in impressing the importance of neatness and attention to detail in their daily street cleaning tasks.

5. That the sidewalks be included with the roadway, and the street cleaned from house line to house line.

6. That the street cleaning implements consist of a broom and shovel for cleaning rough pavements, and a broom and scraper for cleaning smooth pavements. The broom to be made of sufficiently fine material to insure thorough work.

7. The implements used in cleaning the sidewalks to consist of a pan and a horsehair, or other fine broom.

8. That boxes with hinged tops and of sufficient capacity to care for the entire day's output of street dirt, be placed at convenient intervals on the sidewalk, or preferably sunk in the sidewalk, for the temporary storage of the dirt as collected by the street sweeper, and that, for esthetic as well as economic reasons, the street sweepings be collected at night only.

The street dirt is then out of sight and protected from scattering by traffic and the wind. The sweeper can work more rapidly than with the two-wheel cart receptacle.

9. That the roadways be flushed nightly with motor-driven machines, carrying tanks, from which the water is forced out under the necessary pressure to obtain efficient washing of the streets. That the sidewalks be washed by machine, and hand squeegeed nightly, or as often as necessary.

10. That a sufficient number of street sweepers be employed after 4 o'clock, the quitting time of the day force, to pick up the heavy dirt preparatory to flushing the streets, and thus prevent frequent filling of the catch basins, and possible obstruction of the sewers. The adoption of this plan will mean clean streets practically through the twenty-four hours.

Sidewalk Cleaner, Bureau of Street Cleanjng, Inc., Chicago, Ill.

The men required for this service can be estimated roughly as one-tenth of the number employed for cleaning during the day.

11. That the streets be lightly sprinkled through the day, as often as found necessary. The sprinkling should be confined to the gutters, and the space 4 or 5 ft. therefrom, for the tendency of traffic and the slope of the street is to force the dust to the gutter. On streets carrying car tracks, the right-of-way, which collects considerable dust, should also be lightly sprinkled.

12. That when the temperature does not permit of sprinkling, the men sweeping the sidewalks be required to remove any noticeable collections of dust in the roadways. A vacuum cleaner, if it can be made practicable for this purpose, would serve a valuable end.

13. That the functions of sprinkling, flushing, and removal of street sweepings be co-ordinated, if possible, with the collection of waste to obtain the greatest economy in the operation of the power driven equipment now being installed for the latter purpose.

14. That checks on the density of traffic, changes in pavement, the amount of refuse collected by each sweeper, etc., be made from time to time and followed by such

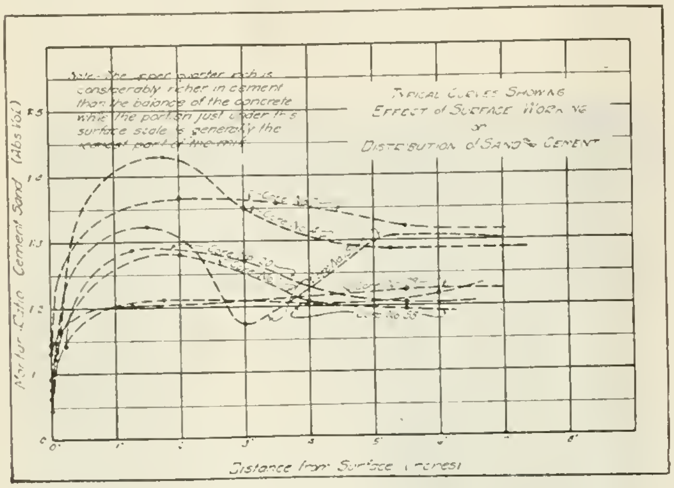
readjustment of the route areas as are found necessary. Also that checks be made at regular intervals to determine if the set standards of cleanliness are being maintained.

## WEAR OF CONCRETE PAVEMENTS DUE TO ABRASION OF MORTAR COAT.*

Even though the surface may be finished with a smooth mortar coat, the coarse aggregate will become exposed as the mortar coat wears away.

If the mortar used is such that it wears at an excessive rate, the aggregate will be quickly exposed and the length of service of the pavement will be materially decreased.

The mortar surrounding the coarse aggregate consists in itself of small aggregate embedded in a matrix of cement paste. For mortars mixed in the laboratories the rules of grading, voids and density, which hold for the coarse aggregate, also apply to the sand. However, for field mortars, especially those deposited with the consistency necessary for paving construction, there is this radical difference: the coarse aggregate can be consolidated by tamping and a considerable part of the excess mortar will be forced from between the pieces of aggregate and flushed to the surface, with the mortar at the consistency ordinarily used, the sand particles, which when dry were in contact with each other, will now be separated by a film of cement paste. The consistency of the mortar is such that tamping will not force any considerable part of the excess cement from between the particles of the sand. Therefore, the addition of cement paste forces the sand grains apart and increases the voids therein to a greater degree than does the addition of mortar increase the voids in the coarse aggregate.



Typical Curves Showing Effect of Surface Working or Distribution of Sand and Cement.

By means of a microscope, the mortars in the pavements under examination were studied to determine the average per cent of volume occupied by the sand grains in pavement mortars of different proportions. Over seventy-five different mortars were studied in this connection, and the curve plotted therefrom. A study of this curve will emphasize the following significant facts:

For mortars richer than 1:3, the addition of cement paste crowds the sand grains further apart, decreasing the absolute volume of sand in the mortar.

That the amount of cement paste available as a void filler increases with the addition of cement at a greater rate than the total voids in the in the sand, and thus the "unfilled sand voids" become less in volume.

That a complete elimination of the "unfilled sand voids" ordinarily occurs only with a neat cement.

The voids designated as "unfilled sand voids" are distinguished from the total voids in that they do not include the voids in the cement paste. In other words, the upper portion of the diagram, representing cement paste, is not a solid material but contains some 40 per cent of voids in itself. The voids in which the pavement engineer is particularly interested, however, are these "unfilled sand voids." This is shown by a study of the photomicrographs of mortars taken from the streets under examination.

In no other concrete construction is the need for a dense matrix more plainly manifest than in the concrete for pavement surfaces. The abrading action of the traffic is particularly destructive to a porous or lean mortar as such action naturally enough finds a point of attack over every sand void in the mortar.

The mortar for pavement surfaces must contain a sufficient proportion of cement to eliminate the probability of an excessive volume of "unfilled sand voids," and the formation of relatively large voids around the individual sand grains. It will be noted that in general the richer the mortar the more completely will the voids in the sand be filled. It does not follow, however, that the use of a rich mixture will result in a low percentage of "unfilled sand voids." It is quite possible, even with an amount of cement which would ordinarily result in a dense mortar, to have an excessive volume of "unfilled sand voids." There are several conditions, aside from a deficiency in cement which increase the porosity of a mortar.

First: A very porous mortar may result from the character of the sand. In mixing the mortar each grain of sand is coated with a film of cement paste, the thickness of which is about the same regardless of the size of the sand grain. Since a given volume of fine sand has a much greater superficial area to be coated than the same volume of a coarse sand, the separating action of the cement film will be much greater with the fine sand. Thus an amount of cement which in a coarse sand would be sufficient to coat the grains and to fill the voids between them might be only sufficient to coat the grains of a fine sand. Air contained in the mass will adhere to the finer as well as to the coarser particles and the finer material will have a less tendency to consolidate.

For the above reasons we would expect the percentage of "unfilled sand voids" with a given cement ratio, to be greater for fine sand than for coarse sand. A study under the microscope of the distribution of sand grains in mortars, fully substantiates such a belief. The lower curve has been plotted through the center of gravity of the results for mortars containing an excess of 50 and 20 mesh material. The higher curve has been plotted for mortars containing considerable 20, 10 and 8 mesh material, as well as finer. The marked increase in the percentage of "unfilled sand voids" for the former grading is at once apparent.

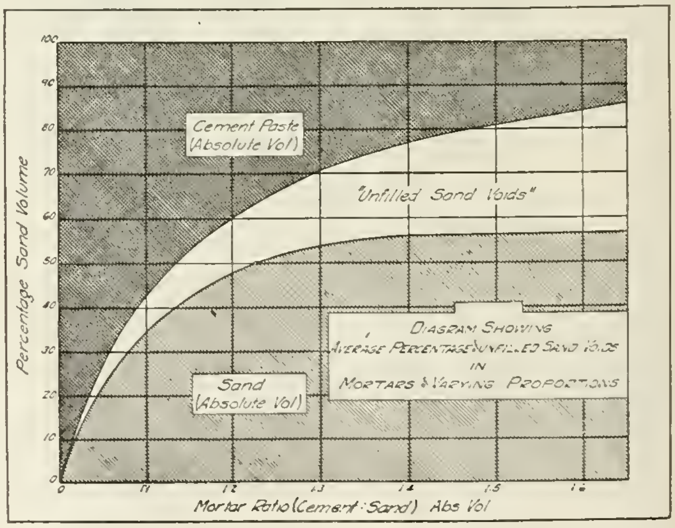


Diagram Showing Average Percentage of Unfilled Sand Voids In Mortars of Varying Proportions.

Second: Proper consistency and thorough consolidation of a mortar, will undoubtedly decrease the volume of "unfilled sand voids." A study of Fig. 3 shows that in the field mortars examined, considerable variation in porosity with mortars of the same proportion was encountered. This may be explained in part by the difference in sand grading as shown in Fig. 2. However, the character of the specimens examined was such as to prove beyond a doubt that the consolidation during construction had much to do with the reduction in porosity.

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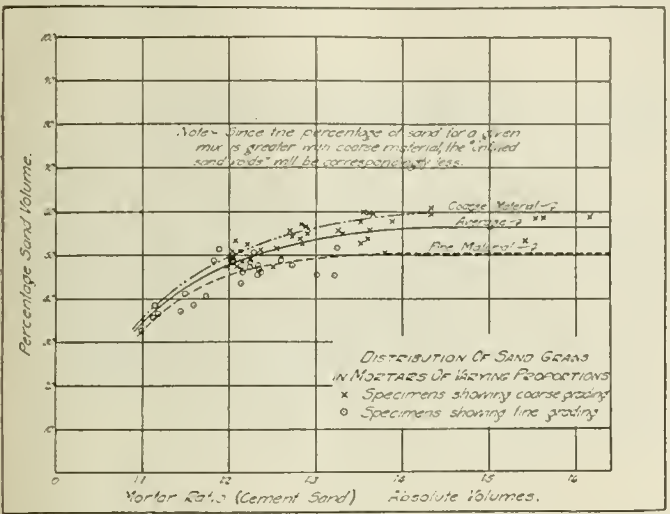
*Discussion based on exact studies of Iowa concrete pavements and published in Technical Report No. 1, Iowa State Highway Commission, by T. R. Agg and C. B. McCullough.

If the mortar is deposited too wet, free water will adhere to the sand grains and to the large aggregate particles. As the mass slowly dries out, water of this character slowly evaporates from the surface, small capillary paths are formed within the concrete and the water is thus released from around the sand grain. This results in many cases, in a mortar wherein the sand grains are more or less completely separated from the cement paste which surrounds them. Such free water may be forced out before the cement has attained its initial set by a thorough tamping.



Distribution of Sand Grains in Mortars of Varying Proportions.

Third: The character of the individual sand grains as well as grading of the same, materially affects the strength of the resulting mortar. In the pavement mortars examined, iron oxide, finely divided clay, dust, or loam, had, in many cases separated the fine aggregate from the cement paste, resulting in poor contact between the sand grains and the mortar.

In summary, the wearing away of the carpet coat discussed under this case is the result of a porous and poorly bonded mortar in which the percentage of "unfilled sand voids" has not been reduced to a safe value. The proportion of cement to sand must insure this as the function of the cement is in part, that of a void filler. The data from the investigation of the streets inspected was such as to indicate that for ordinary conditions of traffic and for ordinary methods of construction a proportion of 1:2.2 (by absolute volume) was about the leanest mortar that could be safely employed for pavement work. This proportion together with careful selection of the fine aggregate, careful regulation of the consistency, a consolidation such as will force to the surface any free water which may be present as a coating or film surrounding the sand grains, and a careful curing of the concrete should result in a surface which will have a normal life under ordinary traffic.

## WEAR OF CONCRETE PAVEMENT DUE TO SCALING OF MORTAR COAT.*

The surface of a concrete pavement may be roughened and the stone exposed to wear by the scaling of the surface mortar. The primary cause of scaling is a broken bond between the mortar covering and the portion of the concrete beneath it. Many conditions cause the bond to break. The discussion which follows is intended to throw some light on the causes of scaling, and to suggest methods by which the same may be eliminated.

Microscopic analysis of the concrete cores shows that the distribution of sand grains throughout the depth of the pavement, seem to vary according to a quite definite law.

First, the top surface for a distance of about ¼ in. is considerably richer in cement than the portions underneath.

Second, that the leanest portion of the pavement is very likely to be immediately under the surface scale.

Assuming the original bond to be perfect, what will be the effect if a hard, dense surface overlays a more porous concrete underneath.

The coefficient of expanion for thermal changes for the dense surface is considered different from that for the porous concrete with a resulting tendency to form horizontal shearing planes.

The rate of absorption, which also influences the expansion and contraction, is considerably different for dense and for porous mortars. This is probably a more important factor than the effect of thermal changes. In periods of continued wet weather, the more porous portions will absorb moisture from the sub-grade, particularly if it be poorly drained, and will tend to expand considerably more than the relatively impervious top scale. Moisture which enters and permeates the pavement from the sides or at the expansion joints, would tend to expand the lower portion more rapidly than the upper, causing differential movements, apparently sufficient in extent to account for any of the scaling encountered during the inspection.

In many cases the bond between the upper and lower layers was probably not originally perfect, being materially weakened by the method of finishing. The action of the trowel in bringing the neat cement to the surface undoubtedly leaves a plane of weakness parallel to the surface at a distance beneath the surface equivalent to the thickness through which the effect of the trowel is transmitted. This plane is in reality a connected line of air voids, produced in a large measure, by the action of the trowel.

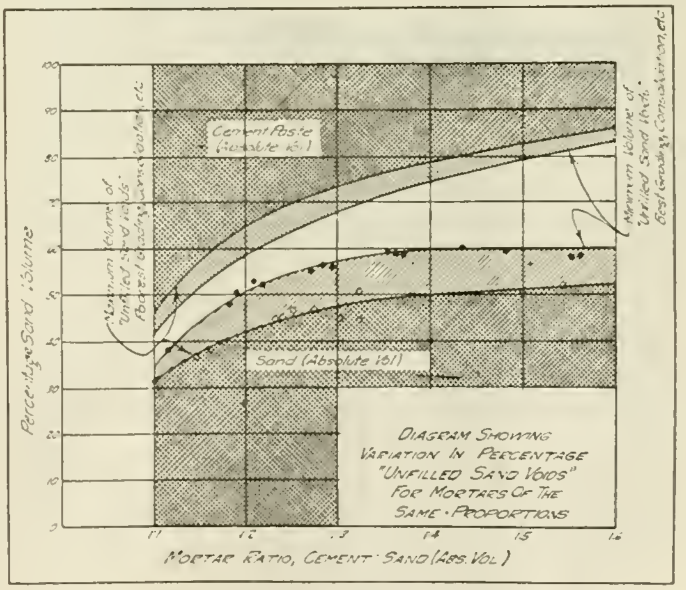


Diagram Showing Variation in Percentage "Unfilled Sand Voids" for Mortars of the Same Proportions.

It is interesting to note that the action of the float or trowel pulls away the top covering from the more porous concrete. The fine materials are brought to the top by a process of flotation and the top surface becomes more dense, more cohesive and assumes a rubbery consistency, quaking under the action of the float and pulling away from the portion underneath. Such a condition may be prevented by a thorough consolidation of the concrete previous to or simultaneously with the striking to proper cross section, followed by only sufficient troweling or floating to smooth the surface.

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*Discussion based on exact studies of concrete pavements in Iowa and published in Technical Report No. 1, Iowa Highway Commission, by T. R. Agg and C. B. McCullough.

Even if the connected line of air voids made by the trowel as above described, are not sufficient to cause a scaling, there are further conditions which may exert a disruptive action sufficient to break loose the surface scale.

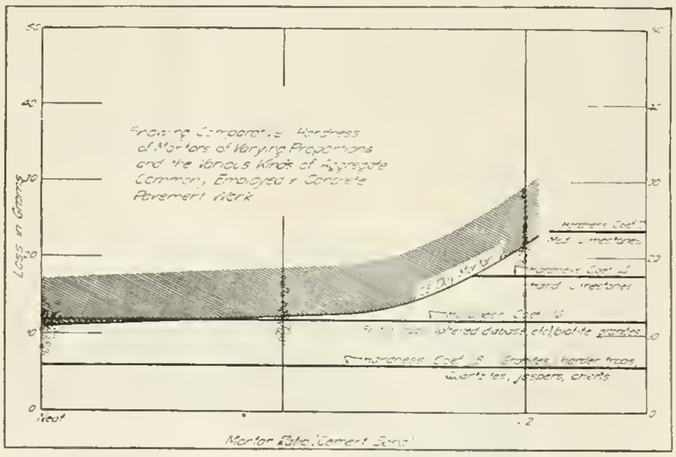
The calcium hydrate which is always present in concrete, may in a porous mortar become segregated in the pores. This calcium hydrate near the surface may change to calcium carbonate with an attendant increase in volume sufficient to break loose the scale. Other causes such as the penetration of street acids and the freezing of water held in the pores may assist in breaking lose surface scales.

The above discussion applies more particularly to the scaling of the hard surface from a more porous mortar underneath. In addition to this certain mechanical conditions which make scaling probable were noted in the examination of the surfaces herein described.

Large flat stone surfaces near the top of the pavement to which the mortar covering is imperfectly bonded, produce a condition favorable to scaling. This thin layer of mortar may become loosened or separated from the stone at intermittent points. Under this condition the mortar scale quickly breaks down.

In general, the methods recommended for the elimination of the defects discussed under Cases One, Two and Three are included under the chapter on specifications and inspection, with the exception of the discussion on correct proportioning which follows.

The data furnished by the inspection of the pavements and the microscopic analysis of the surface mortars show that mortars containing not less than one part cement to 2.20 sand (absolute volume) have shown no excessive wear, when the other details of construction were properly carried out.



Showing Comparative Hardness of Mortars of Varying Proportions and the Various Voids of Aggregate Commonly Employed in Concrete Pavement Work.

From the curve of Fig. 1 we find that for average conditions such a mortar will contain 50 per cent of sand grains. The absolute volumes in a unit volume of mortar will then be .227 cement to .50 sand.

The absolute volume of stone which can be carried by this volume of mortar is given above. Substituting in the formula we arrive at the following proportions, by absolute volume:

$$.227 : .50 : \frac{.97[1-(G+P)]}{.97[(G+P)+.03]}$$

Transforming to loose volume on the assumption that: One sack (94 lbs.) of cement contains a loose volume of 1 cu. ft. and that 1 cu. ft. of sand under ordinary conditions contains 89 lbs. of sand grains, we have the following proportions by loose volumes:

$$\begin{array}{ccccc} \text{Cement.} & & \text{Sand.} & & \text{Stone.} \\ \frac{.227 \times 3.10 \times 62.5}{94} & : & \frac{.50 \times 2.65 \times 62.5}{89} & : & \frac{.97[1-(G+P)]}{[.97(G+P)+.03](1-G)} \end{array}$$

Evaluating these proportions, we arrive at the results in the following table:

TABLE 1.

| Voids in original stone. | Correct proportions by loose volume.<br>Cement. | Sand. | Stone. |
|---|---|---|---|
| 30 per cent | 1 | 2 | 3.24 |
| 35 per cent | 1 | 2 | 3.22 |
| 40 per cent | 1 | 2 | 3.16 |
| 45 per cent | 1 | 2 | 3.10 |

It is apparent that due to the increased spreading action of the mortar in stone having a low percentage of voids (see Fig. 2), there is but little difference in the amount of stone needed, even for considerable variation in total voids. It also appears that a 1:2:3 mixture has more to recommend it than a 1:2:3½ and that until further refinements in the methods of field proportioning are generally used, it is unnecessary to provide for varying the proportions for stone of different void contents.

The above proportions have been calculated on the assumption that the mortar shall be sufficient to fill all the voids, and in addition, furnish all the material for a carpet coat ¼ inch thick.

When the two course type of construction is employed, a method of reasoning, similar to that employed for the one-course type, but using instead a 1:1 mortar, leads to a proportion of about 1:1:1½ for the wearing course.

The selection of the type of construction will usually be dictated by the consideration of first cost. The two-course type requires more cement per square yard, but where a coarse aggregate of high quality is expensive, this type, using the expensive aggregate for the wearing course only and local or cheaper materials for the base course, will prove the cheaper.

Aside from considerations of cost a study of the texture of the surface mortars in place, furnishes data which would justify a prediction of longer life, especially under heavier traffic conditions for mortars mixed richer than 1:2.

The nature of the discussion which forms the subject matter of this chapter, is such as to indicate that the life of a concrete pavement depends to a large degree on the correctness and uniformity in the proportioning of the materials. Emphasis should be laid on the fact that the present methods of field proportioning are exceedingly crude. The development of the bituminous pavement surface has been characterized by the adoption of accurate methods of proportioning and grading the materials. Concrete as a surfacing material will never be used at its highest efficiency until the proportions are specified by weight and these proportions accurately maintained as the materials are placed in the mixer.

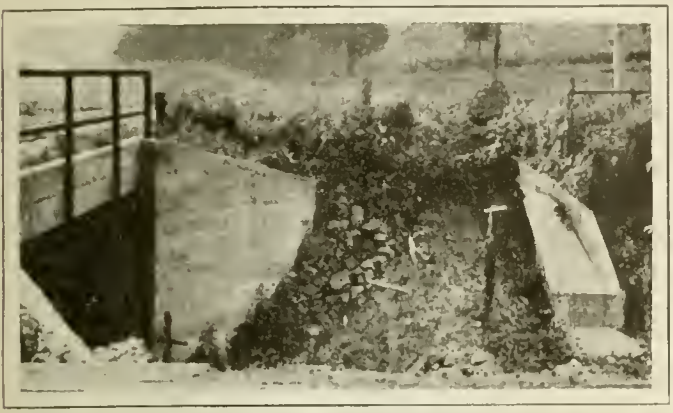
## HANDLING SURFACE AND SUBSURFACE DRAINAGE.

A combination system was used for draining the surface and subsurface of a highway constructed recently up a very steep hill in the town of Salisbury, Conn. The work was described by Charles J. Bennett, state highway commissioner of Connecticut, in a lecture delivered in the Graduate Course in Highway Engineering at Columbia University. The old road was practically only wide enough to accommodate one vehicle and had constituted itself a drainage canal for the surrounding country. After every rain, the road surface was entirely washed out and the construction of a road in this vicinity was approached with some misgivings. It was decided that no matter how much it might cost the drainage must be properly taken care of, and therefore, a combination of two systems of disposing of the surface water was devised. First, the road surface itself was built on top of a stone fill about 4 ft. in depth at the bottom of which an open box culvert was installed to carry whatever water might enter beneath the road from the sides. The stone fill was extended to the extreme width of the road itself, that is, from shoulder to shoulder, and extremely deep and wide ditches were provided at the side of this road to accommodate the water that came from the road surface and from other sources.

The rubble drain was apparently separated from the base of the rock fill by a rise in the subgrade. Leak-offs were made from this fill into the rubble drain though in many instances the rubble drain followed the center of the road, but the intention was to provide not only surface and subgrade drainage from the road itself, but to keep off the surface drainage from the slopes. No trouble has occurred since the road was built and the drainage system is successful, even if a trifle expensive. It is interesting to note also that no attempt was made to cut the top of the hill, but the entire slope was filled with stone as noted.

## FLUME FOR PREVENTING EROSION.

The accompanying illustration, reproduced from the August Minnesota Highway Journal, shows a method employed in Wabasha County, Minnesota, for preventing erosion at the point where the road gutter enters a stream or ravine. The water is carried to the bottom of the run in a concrete flume, the front of which is protected against underwash by aprons and riprap.



Cenerete Flume for Preventing Erosion.

## ROCK ASPHALT PAVING MIXTURE AT SALT LAKE CITY, UTAH.

During 1915 the city of Salt Lake City, Utah, constructed 2.4 miles of rock asphalt pavement, the Utah asphalt being used. In the construction of the pavement this pure rock asphalt was not used directly, but was mixed with properly graded sand and California refined asphalt. As a result it is stated the density and stability of the pavement were increased, and the proper penetration was obtained as well as a more uniform paving material. In general the top was 1½ in. thick, the binder course 1½ in. and the concrete base 6 in. The average cost in 1915 per square yard was $1.85. A 5-year guarantee was required. This cost does not include grading which was paid for separately at an average cost of 65 cts. per cubic yard. The concrete base was a 1:3:6 mix, the cement costing $2.25 per barrel, broken stone $1.50 per cubic yard and sand $1.50 per cubic yard. Common labor was paid for at the rate of $2.25 per 8-hour day and teams and drivers at the rate of $5 per day. The accompanying tabulation (Table I) taken from the annual report of Sylvester Q. Cannon, City Engineer, shows the test averages of the rock asphalt mixture as used last year.

## RECOMMENDED PAVEMENTS FOR BOSTON, MASS.

A committee of engineers, consisting of James H. Sullivan, H. J. Hughes, Guy C. Emerson, Arthur W. Dean and John R. Rablin, was appointed this spring by the mayor of Boston, Mass., to make recommendations as to the policy to be followed by the city in the surfacing of the streets. The committee submitted its report on June 15.

For purposes of the report the streets were divided into six classes, namely:

(1) Heavy Traffic Streets; that is, streets carrying a large volume of heavy trucking.

(2) Main Arteries; that is, main radial highways leading to and from the city proper and carrying heavy traffic.

(3) Retail Shopping and Office Building Districts.

(4) Residential Districts (city proper).

(5) Residential Districts (suburban).

(6) Park Roads.

The types of surfacing recommended for the various classes of streets were as follows:

Class 1—(heavy traffic streets): Granite blocks laid on Portland cement concrete base not less than 6 in. in thickness, the joints to be filled with Portland cement grout; in the case of excessive grades, pitch to be substituted for grout in the upper inch or so of the joints, in order to provide better foothold for horses.

Class 2—(main arteries): The same type of pavement as Class 1, with a few exceptions where the surroundings require a smoother and less noisy surface, such as wood blocks or the best grades of bituminous pavements.

Class 3—(Retail shopping and office building districts): Treated wood block pavements, the best grades of bituminous, pavements on a Portland cement concrete base. At the present time the only wood recommended for wood-block pavements is long-leaf yellow pine.

Class 4—(Residential districts in the city proper): Treated wood-block pavements, the best grade of bituminous pavements or Portland-cement concrete pavements; the choice to be determined by the intensity and character of the traffic.

Class 5—(Suburb and residential districts): Cheaper types of bituminous pavements, using old macadam surfaces for the base where suitable, or Portland-cement concrete pavements.

Class 6—(Park roads carrying only pleasure traffic): Bituminous pavements using old macadam for the base where suitable, or Portland-cement concrete pavements.

The committee deemed it inadvisable and unnecessary to prepare new specifications for the pavement recommended in view of the fact that most excellent specifications have been carefully prepared after thorough discussions by experts, and adopted by organizations of high standing. It was recommended that paving work done by the city and the provisions and requirements of any guarantees relating to such work should conform substantially to specifications adopted by the American Society of Municipal Improvements, for granite block, wood block and bituminous pavements; for Portland cement concrete surfaces the work should conform substantially to the standard specifications of the American Concrete Institute.

TABLE I.—TEST AVERAGES, ROCK ASPHALT MIXTURE, SALT LAKE CITY.

| | 60% Utah Rock Asphalt | | | | | | | | | | | | 40% Refined Asphalt and Sand | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Asphaltic cement added. | | Asphaltic concrete binder | | | | | | | Asphaltic wearing surface mixtures. | | | | | | | | | | | |
| | | | | | | | | | | | | | | Per cent of sand passing standard sieve. | | | | | | | | | | |
| 1915. Extensions and location. | Per cent bitumen in rock | Per cent ref. asphalt and sand | Penetration bitumen in rock | Kind | Penetration in cms. | Per cent bit. sol. in $CS_2$ | Per cent sand passing 10 mesh | Per cent stone passing ¾ inch | Per cent stone passing 1 inch | Penetration A. C. in cms. | Temp. of street in deg. F. | Thickness in inches | Per cent bit. sol in $CS_2$ | 200 mesh (filler) | 80 mesh | 40 mesh | 10 mesh | 4 mesh | Temp. of sand at plant, Deg. F. | Temp. of A. C. at plant, Deg. F. | Pen. A. C. at tank in cms. | Temp. of street in Deg. F. | Thickness in inches | Number of tests |
| 36-100. 8th West—2 to 10 S. | 8.50 | 40 | 48 | Cal. D.X. | 72 | 5.10 | 10.15 | 62.58 | 22.17 | 72 | 260 | 1.0 | 11.37 | 12.68 | 23.20 | 24.35 | 20.52 | 6.88 | 275 | 310 | 72 | 265 | 2.0 | 75 |
| 36-112. 6th East—5 to 9 S. | 12.00 | 40 | 120 | Cal. D.X. | 50 | 5.34 | 5.08 | 74.38 | 15.20 | 50 | 270 | 1.5 | 11.27 | 15.44 | 23.12 | 20.74 | 24.85 | 4.58 | 300 | 300 | 50 | 285 | 1.5 | 40 |
| 36-106. 6 E.-3 to 4 S. and 4 S. | 12.06 | 40 | 120 | Cal D.X. | 48 | 5.14 | 11.15 | 71.10 | 12.61 | 48 | 265 | 1.5 | 10.87 | 15.32 | 22.60 | 21.75 | 24.70 | 3.76 | 280 | 310 | 48 | 280 | 1.5 | 14 |
| 36-57. 3rd West St. | 12.50 | 40 | 120 | Cal. D.X. | 50 | 5.02 | 6.25 | 86.00 | 8.73 | 50 | 260 | 1.0 | 12.45 | 20.52 | 26.70 | 20.30 | 11.90 | 5.13 | 275 | 290 | 50 | 270 | 2.0 | 15 |
| Actual average | 11.25 | 40 | 102 | | 55 | 5.15 | 8.16 | 72.01 | 11.68 | 55 | 264 | 1.2 | 11.49 | 15.39 | 24.40 | 21.79 | 21.24 | 5.09 | 282 | 302 | 55 | 275 | 1.8 | |

## REMOVING OLD PAVEMENT AND CONCRETE BASE WITH STEAM SHOVEL.

The laying of an improved granite pavement on Broadway, Borough of Brooklyn, New York City, involved a number of interesting constructive features. Chief of these was the use of a steam shovel for ripping up the old wood block pavement and the 5-in. concrete base.

The shovel, which was manufactured by the Keystone Driller Co., of Beaver Falls, Pa., has a ½-yd. bucket and a boom so placed that it can be lowered parallel to the ground. The bucket slid along the boom and scooped up the wood blocks and loaded them into dump wagons. The concrete base was handled in the same way. The shovel, despite many delays due to traffic conditions, removed about 700 sq. yd. of blocks per day. On the concrete base it averaged from 500 to 700 sq. yd. of concrete base. The operating force consisted of an engineer and fireman; and a foreman and two laborers. The latter were employed in laying plank for the shovel to move over under its own power and for leveling up.

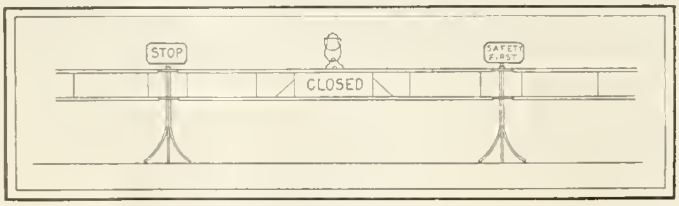
Steam Shovel Excavating Pavement and Concrete Base.

The shovel was followed by a gang of laborers who brought the street to the required grade, which was about 3 in. below the old one. This grade was then compacted by a 10-ton steam roller and the 6-in. concrete base placed, the mixing being done by a Koehring paver. The blocks were laid on a 1-in. sand cushion. The blocks were of the latest improved smooth head ⅜-in. joint type, 3¾ in. to 4¼ in. wide, 4¾ in. to 5¼ in. deep and 8 to 12 in. long. No pea stone was used in the grout, a 1 to 1 tar and sand filler mixed in a batch mixer being used.

The pavement was laid between Havemeyer St. and Myrtle Ave. and amounted to about 34,464 sq. yd. Work on it was started the latter part of May. The contractor was the Charles A. Myers Contracting Co. of Brooklyn.

## A METAL STREET BLOCKADE.

The street or road baricade shown in the accompanying drawing has just been placed on the market by the C. C. Fouts Co., Middletown, O. The baricade is made of metal. The stand consists of ½-in. pipes welded together, and is 3 ft. high. The ladder portion is supported on pins in a frame welded to the posts. The gate post is 10 ft. in length and 8 in. wide. The targets are 9 in. wide by 15 in. long.



Metal Road Blockade.

## FILLER FOR GRANITE BLOCK PAVEMENT.

A special filler for use in granite block pavement construction has been developed by Mr. Bruce Aldrich, Chief Asphalt Inspector of the city of Baltimore, Md. This filler has been used with excellent results by the Paving Commission of that city.

This filler is refined from Mexican crude oil and has the following characteristics:

| | |
|---|---|
| Bitumen soluble in $CS_2$ | 99.80% |
| Bitumen soluble in $CCl_4$ | 99.80% |
| Specific gravity, 60° F | 1.042% |
| Penetration at 32° F | 17 |
| Penetration at 77° F | 45 |
| Penetration at 115° F | 160 |
| Ductility at 77° F | 50 c.m. |
| Loss 325° F., 5 hrs., 20 grm | None |
| Penetration at 77° F., after this | 32 |
| Per cent hardened | 28.8 |
| Melting point, cube method | 115° F. |

To obtain best results when using this filler the granite blocks are laid with close joints (not over ½ in.) on a bed consisting of 1 part Portland cement and 4 parts of clean, screened, sharp sand, with a depth of 1 in. The surface of the pavement is covered with hot torpedo gravel, which is swept into the joints to a depth of about 1 in. The blocks are then rammed, after which the joints are poured half full with asphalt block filler. They are then filled to within ½ in. of the top of the blocks with torpedo gravel and again poured with filler, which flows over the blocks, covering the entire surface of the pavement. Hot gravel is then thrown over the surface, which can in a few hours be opened to traffic. In fact the sooner the better, as the action of the horses' feet and wagon wheels tends to caulk the material into the joints.

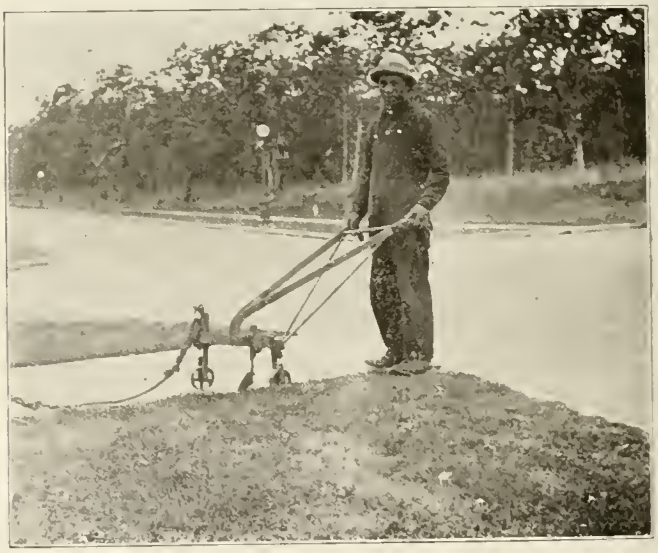
In using this filler care should be taken to have it at a temperature between 375 and 425° F., as it will not penetrate and fill all interstices if poured at a lower temperature.

It is also imperative that the blocks should be perfectly dry and free from dust, as the filler will not adhere to a wet or dusty surface.

## TOOL FOR REMOVING SOD FROM EDGE OF CONCRETE WALK.

Contributed by H. R. Ferriss, Victoria, B. C.

In a finely kept estate which our company owns, there are about 19,000 lin. ft. of concrete walks, over both edges of which the adjoining turf had grown, in places as much as 8 ins. In order to reduce the cost of hand trimming, it was decided to remove a strip of sod about 1½ in. wide by 3 in. deep from both edges of the walk, and as there seemed to be no tool in the market which would do this work efficiently and cheaply, the device shown in the illustration was made. The "plow" was designed and made by the "handy-man" employed on the estate. The wheels and handles were taken from a "scrapped" horse-mower, and the other parts were forged in the shop.



"Home Made" Plow for Removing Sod.

The "plow" worked by two men, one holding the handles, and one particularly husky chap pulling with a rope, removed a neat strip of sod of uniform width, for the following cost:

COST OF EDGING 38,000 LIN. FT. OF SOD.

| | | |
|---|---|---|
| Cost of plow— | | |
| Labor | $ 3.25 | |
| Materials (not including old parts) | 1.00 | $ 4.25 |
| Labor— | | |
| Edging, 72 hr. at 20 ct. | 14.40 | |
| Cleaning up and removing sod, 63 hr. at 20 ct. | 12.60 | 27.00 |
| | | $31.45 |
| Total cost per 1,000 lin. ft., 83 ct. | | |

The sod had to be removed a considerable distance in wheelbarrows as the adjoining property is privately owned.

## CONCRETE MIXER USED FOR ROLLING SUB-GRADE.

In connection with some paving work at Glenwood, Ia., the contractor, Mr. Samuel Friedman, Keeline Bldg., Omaha, Neb., used his paving mixer for rolling the subgrade. The accompanying illustration shows the mixer operating as a roller. One-half inch steel tires, 30 in. diameter, butt welded, and 24 in. length, were slipped over the regular mixer wheels, and the outer half of each tire filled with cement and sand mixed in the proportions of 1 to 2. The entire cost was approximately $75. Mr. Friedman writes that an excellent compression was obtained with the rolls. The mixer was a Chain Belt paver, manufactured by the Chain Belt Co., Milwaukee, Wis.

Concrete Mixer With Roller Wheels, Compacting Subgrade.

## MOTOR TRUCK, SCARIFIER AND ROAD GRADERS ON GRAVEL ROAD MAINTENANCE.

The maintenance of 450 miles of gravel roads in Montgomery County, Alabama, is under the direction of Mr. Thomas H. Edwards, County Engineer, who has effected remarkable reductions in maintenance costs. The county now has five White trucks (5-ton, 6-cylinder), a fleet of Troy reversible trailer wagons and a fleet of Road King, Russell, Western and Ohio Reversible road graders.

A motor truck with three road machines covers 30 miles a day at the following cost per day, exclusive of interest, depreciation and repairs:

| | |
|---|---|
| Truck driver | $3.00 |
| Laborers, 3 at $1 | 3.00 |
| Foreman | 3.00 |
| Gasoline, 20 gal. at 25 ct. | 5.00 |
| Oil, 2 gal. at 50 ct. | 1.00 |
| Total for 30 miles at 50 ct. | $15.00 |

A round trip with the fleet of three road machines completely resurfaces a gravel road after a rain, at a cost of 50 ct. per mile of road exclusive of interest, depreciation and repairs.

Where a road has worn into ruts and hollows, scarifying is necessary before scraping. The cost of scarifying a mile of road is about as follows:

| | |
|---|---|
| Labor, 5.25 days at $1 | $5.25 |
| Truck driver, 1.15 days at $3 | 3.45 |
| Foreman, 1.15 days at $3 | 3.45 |
| Gasoline, 25 gal. at 25 ct. | 6.25 |
| Oil, 6 gal. at 50 ct. | 3.00 |
| Total | $21.40 |

The width scarified is about 12 ft. In addition to this the cost of shaping the surface, using a truck hauling one road machine, is about $2.50 per mile of road, making a total of about $24 per mile.

On the average the 450 miles of gravel roads require scarifying and shaping of the surface about once annually. The surfacing after rains (without scarifying) is done about 15 times annually on the average road.

## CONFERENCE ON BRICK PAVEMENT CONSTRUCTION.

The National Paving Brick Manufacturers' Association will hold a study and conference on brick pavement construction, Oct. 6, at Paris, Ill. The headquarters will be the Deming Hotel, Terre Haute, Ind., from which place those participating will go via interurban railway to Paris, Ill.—an hour's ride—where the construction demonstration will take place.

The demonstration will consist largely of steps showing the economy of construction details in building a brick pavement by laying the brick in green mortar. An important purpose of the effort will be to show how such a pavement can be built with the least possible cost and yet maintain all the essentials of worth.

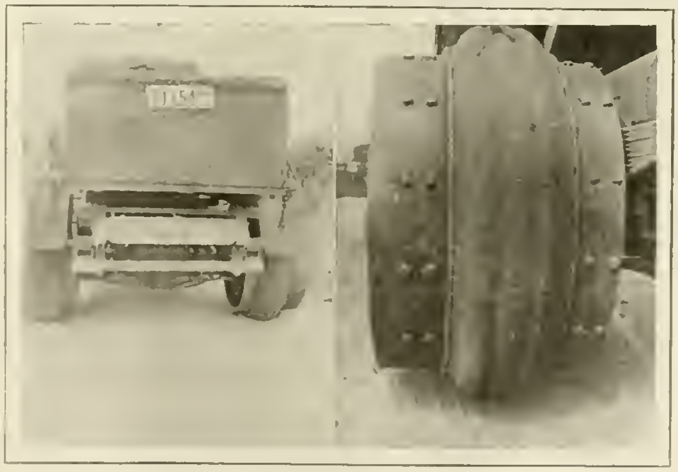
All persons connected in any way officially or those deeply interested in the roads of this country will be made welcome at this conference. It is undertaken, no less in behalf of the brick industry, than in the sincere belief that the country itself is bound to be profited by such an opportunity.

Members of the American Society of Municipal Improvements on their way to the annual meeting of that society can spend Oct. 6 at this conference and reach Newark, N. J., the following Monday.

The conference will be characterized by a critical study of what may be seen in every phase of the construction and the finished pavement. All those expecting to take advantage of this opportunity are requested to notify the secretary of the association, Will P. Adair, Cleveland, O., in order that they may be fully informed of the program, arrival and departure of trains, etc.

## EXTENSION WHEEL RIMS FOR MOTOR TRUCK.

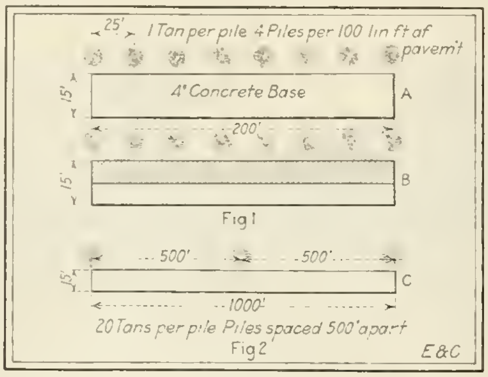
Mr. Albert E. Gray, a contractor of Goodland, Ind., has equipped the rear wheels of his 3½-ton service motor truck with extension rims as shown in the accompanying illustration. The truck has 36-in. x 10-in. Firestone tires. The rim on the inside of the wheel is 31 in. by 4 in. wide, and on the outside 31 in. by 6 in. wide. The rims have proved exceedingly useful in loose stone, sand, or on earth roads where the truck has run in the same track on each trip.



Extension Rims on Motor Truck Wheels.

## METHODS AND COSTS OF CONSTRUCTING BITUMINOUS SURFACED CONCRETE ROADS IN CALIFORNIA.

The act of 1909, under which California began the building of a state highway system, provided $18,000,000 and called for the construction of nearly 2,900 miles of roads. The State Highway Commission therefore was confronted with the problem of providing improved roads at an average cost of approximately $6,200 per mile, this sum including expenses of every nature. In order to effect a most vital economy and to conserve as far as possible the available funds the commission adopted for a considerable part of the mileage a road surface consisting of a $\frac{1}{2}$-in. bituminous top composed of heavy asphaltic road oil and screenings placed on a 4-in. concrete base. Many miles of this construction have been completed, and it is stated for average highway traffic the bituminous carpet has begun to demonstrate that it is an exceedingly economical and successful type of surfacing.


25'
1 Ton per pile 4 Piles per 100 lin ft of pavem't
15'
4" Concrete Base
A
200'
15'
B
Fig 1
500'
500'
15'
C
1000'
20 Tons per pile Piles spaced 500' apart
Fig 2
E&C

Figs. 1 and 2—Methods of Spreading Screenings. Fig. 1 shows hand spreading method. One strip of concrete base 7$\frac{1}{2}$ ft. wide has just been oiled and laborers are throwing screenings from small stock piles. Fig. 2 shows machine spreading method. A small hopper discharging into 30-in. revolving disc is attached to rear end of truck body. Two laborers with truck feed screenings to hopper and load truck from stock piles.

In a recent report to Mr. Austin B. Fletcher, State Highway Engineer, Mr. W. C. Howe, Division Engineer of the commission, gives some interesting details regarding the method of construction, costs and durability of the bituminous surfaced concrete. His information is based on experience gained in the construction of 400,000 sq. yd. of this surfacing in Division V of the state highway system between Salinas and Santa Barbara. The main features of the report follow:

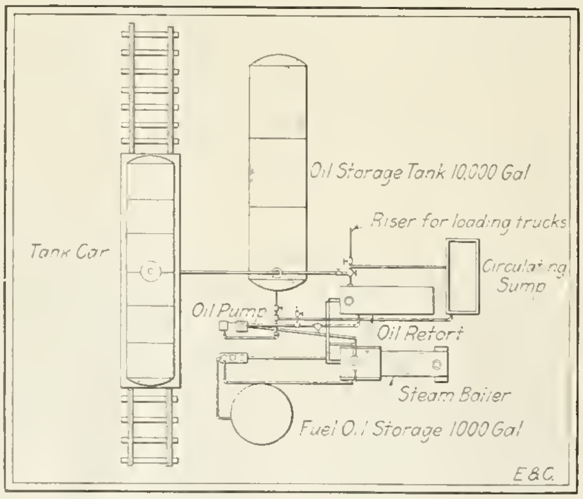


Fig. 3—Oil Heating Plant.

The equipment necessary to apply this wearing coat in the most economical manner consists simply of the following:

1. A semi-portable oil heating plant, one arrangement of which, together with the necessary items, is shown in Fig. 1.
2. One or two—preferably two—5 or 6-ton motor trucks, with power dump bodies, one of which is interchangeable with a 1,000-gal. pressure oil distributor which is operated by truck motor.
3. One 9-ft. broom, horse-drawn street sweeper.
4. Set of car unloading chutes or portable bunker of sufficient capacity to hold 12 tons of screenings.
5. Lot of small tools such as shovels, round and square point, broad-blade hoes, fiber and steel stable brooms, etc.

With such an outfit, costing about $12,000, approximately 3,000 sq. yd. of completed surfacing can be laid daily under average conditions for about eight or nine months of the year in California; or say a yearly output of 600,000 sq. yd. The life of the equipment without excessive repairs is about 5 years. With interest at 6 per cent and depreciation at 20 per cent this fixed charge per square yard of surfacing would be about $\frac{1}{2}$ of 1 ct., based on the output noted.

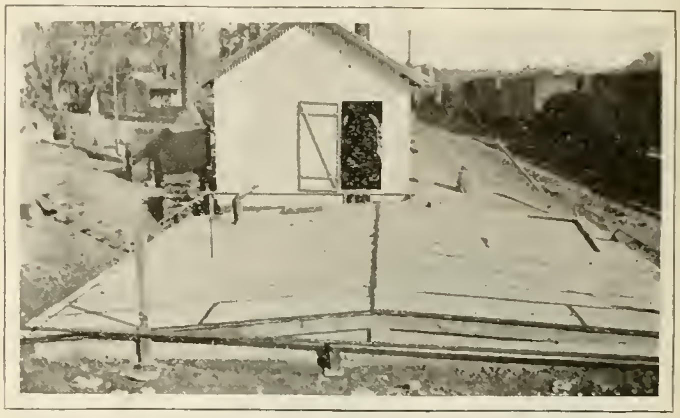


Fig. 4—Permanent Oil Heating Plant.

The size of crew used in this work varies from 10 to 18 men, with a 2-horse team for the sweeper. The following scale is a fair average of the wages paid to an experienced organization:

| | Per day. |
|---|---|
| Foreman | $5.00 |
| Oil plant operator | 4.50 |
| Motor truck drivers | 4.00 |
| Oil distributor operator | 3.00 |
| Skilled labor (covering oil) | 2.50 |
| Teamster | 2.50 |
| Common labor (unloading cars, etc.) | 2.25 |
| Two-horse team | 2.25 |

A description of the work on one section of highway will best describe the cycle of operations.

About two or three weeks before the actual application of oil was contemplated, the two motor trucks were put in service hauling screenings from cars at railroad sidings, and spotting the same along the pavement in convenient piles. Two methods of spotting piles of screenings were used, as shown in Fig. 2.

Fig. 5—Pavement Strip Ready for Oil.

At this same time, the equipment comprising the oil heating plant was shipped to the job. A location approximately in the center of the section to be oiled, alongside a railroad siding, was utilized for oil plant site, and the heating plant, similar in arrangement to plan in Fig. 1, was erected. Four men, a foreman at $4.50 and three laborers at $2.50 each, made the complete installation in ten days.

A few days before the arrival of the first car of oil, a crew of eight men each equipped with a hoe, a square point shovel and a stable broom, went from one end of the pavement to the other, scraping loose and brooming off all earth and detritus adhering to the pavement (tightly packed earth and manure will not be removed by the rotary broom).

Everything being in readiness to commence oiling operations, one of the motor trucks having been equipped with the oiling apparatus, and hot oil being available at the oil plant, the pavement crew (eight to ten men and 2-horse team on sweeper) prepared a strip of concrete one-half the pavement width for a length of 4,400-4,500 ft., by careful brooming to remove dust film and dirt. One of the most important steps in placing this surfacing is this work of cleaning the concrete, and it must be done thoroughly. The hot oil was then sprayed on this strip at the rate of $\frac{1}{4}$ gal. per square yard, the oil being at a temperature of 275° to 325° F. at the time of application. The pavement crew, strung along with 300 to 400-ft. intervals between the men, immediately covered the oil roughly with a light coat of screenings and as soon as the oil was completely covered, the horse-drawn sweeper, with broom locked against revolving, was driven back and forth the length of the strip until the screenings presented a smooth, uniform appearance.

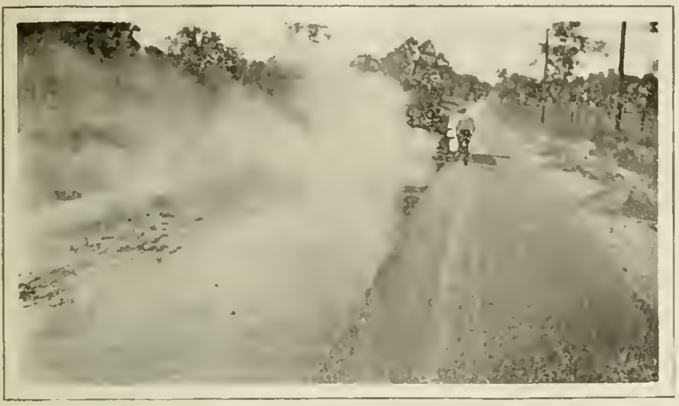


Fig. 6—Applying Hot Oil.

The traffic was then turned on to this oiled and screened strip and the remaining half of the concrete pavement was closed to traffic and cleaned to receive its coat of oil.

In this manner, viz.: a single application of $\frac{1}{4}$ gal. of oil per square yard in successive strips, each about 4,200 ft. in length, first one one-half and then on the adjoining one-half of the pavement, the work was carried forward until the entire pavement had received a first coat of oil and screenings; the traffic being allowed to pass over a strip as soon as thoroughly covered with screenings.

A second coat of oil and screenings exactly similar in quantity and method was then applied over the whole section on top of the first coat, care being used to sweep the initial covering clean of loose screenings or dust before applying oil. With the completion of this second coat, the bituminous surfacing was practically abandoned to traffic, one man and a small wagon and horse being left on the work to add additional screenings wherever oil showed signs of working to the surface. This care against "bleeding" was maintained for about three weeks, and in a short time thereafter the traffic had given the surfacing a smooth, uniform asphaltic appearance.

The use of coarse sand for the second coat in place of screenings has been tried with apparently satisfactory results, but it is Mr. Howe's belief that the use of good, hard broken stone screenings, free from the dust of fracture, for both coats of oil will make a more lasting and satisfactory surfacing than the sand.

A brief summation of costs of the Highway Commission's surfacing above described, is herewith given. These items of costs are averages taken from seven different jobs, the smallest of which covered 12,800 sq. yds., and the largest 116,000 sq. yds., the total being about 400,000 sq. yds.

AVERAGE COSTS.

| | Per sq. yd. of pavement. |
|---|---|
| *Unloading screenings | $0.0035 |
| Hauling and piling screenings | 0.0130 |
| *Spreading screenings on oil | 0.0037 |
| *Unloading tank cars and heating oil | 0.0056 |
| Hauling and spreading oil | 0.0050 |
| *Cleaning surface to receive oil | 0.0040 |
| Screenings (cost f. o. b. cars railroad sidings) | 0.0325 |
| Asphaltic oil (cost f. o. b. cars railroad sidings) | 0.0142 |
| *Interest and depreciation | 0.0045 |
| *Supervision and overhead | 0.0025 |
| Total cost per sq. yd. | $0.0885 |

*These items vary but little no matter what the location of the work. Other items are variable and depend upon length of haul, nearness to source of supply, etc.

This table includes the cost of all repairs to equipment, together with the full cost of all incidental tools, etc.

It has been freely prophesied that this surfacing will have a life of from three to four years with moderate repairs. That it will have even a longer life is now very probable, and such repairs as have been made in the case of the 400,000 sq. yds. previously mentioned, will amount to less than $200, or about $0.0005 (one-half mill) per square yard, and some of this surfacing is almost 2 years old. With the exception of one small piece of surfacing containing a few thousand square yards, which was improperly put down due to adverse conditions, all of the 400,000 sq. yds. is in excellent condition at this writing.

If it became necessary to replace this surfacing every 4 years, it should be borne in mind that such replacement could be made time after time, six, seven, or even eight times, before the cost of one surfacing with standard sheet asphalt would be approached. In other words, at an equal cost with standard sheet asphalt surfacing, the thin bituminous covering used by the California Highway Commission would have a life (by replacement) of at least 30 years with very moderate maintenance.

In conclusion, an expensive surfacing would very quickly have exhausted the highway bond issue fund, while replacements of the thin bituminous surfacing can be made from year to year as necessary from the maintenance fund provided by the motor vehicle tax, and the people thus directly benefit by the increased mileage of permanent smooth highway over which they may travel.

The following photographs are illustrative of the work and equipment described therein. Fig. 4 shows a permanent installation of one of the Commission's oil heating plants. The covered road oil storage tank in foreground has a capacity of 25,000 gal. The steam boiler and road oil pump are in the little building, to the left of which appears the oil retort or heater.

The oil is shipped in tank cars containing pipe coils. Upon arrival at plant, connection is made to this pipe coil and the oil heated until it will flow into storage tank. The storage tank contains a large amount of steam coil and here oil is heated to about 200° F. The hot oil is then pumped through retort where its temperature is raised to 350-373° F., at which degree it goes into motor truck tank.

Figure 5 shows one strip of pavement that has just been given a coat of oil screenings. The contiguous strip has been cleaned ready for the arrival of the truck with hot oil. In Fig. 6 the hot oil is being applied to the concrete, shown in the preceding view.

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## ANNUAL CONVENTION OF SOCIETY FOR STREET CLEANING AND REFUSE DISPOSAL.

The annual convention of the Society for Street Cleaning and Refuse Disposal, of which Joseph R. Buchanan, Municipal Bldg., New York City, is Secretary, will be held Oct. 13 and 14 in New York City. The business sessions will be held in the building of the New York Department of Street Cleaning, on 20th St., between 6th and 7th Ave. The annual convention of the Society of Municipal Improvements will be held in Newark, N. J., on Oct. 9-13, and as some of the members of that society also are members of the Society for Street Cleaning and Refuse Disposal it was thought desirable to select a time for the convention that would make it possible for such members to attend both conventions on the trip to the east.

## STREET CLEANING WITH POWER DRIVEN STREET SWEEPERS AT LOS ANGELES, CAL.

The city of Los Angeles, Cal., may use vacuum street sweepers for cleaning its paved streets. Specifications prepared recently by Homer Hamlin, City Engineer of Los Angeles, Cal., preparatory to letting a contract for sweeping the paved streets of the city with power driven street sweepers, provide that the sweepers shall be suction or vacuum pickup type or any power driven type which satisfactorily gathers up the dirt and transports it to a predetermined dumping point.

A trial of vacuum sweepers was made in Los Angeles early this year. A "Baxter" sweeper was operated three months (February, March and April) and swept approximately 3,010,500 sq. yd. net of paved surfaces per month at a cost of 16.5 ct. to 17 ct. per 1,000 sq. yd., the hire of the sweeper being $500 per month. The manufacturers offered to sweep the streets at a cost of 10 ct. per 1,000 sq. yd., but did not state the basis on which the area swept was to be computed.

In the trial the sweeper was used in the down-town semi-business and hotel district. On account of the traffic interference it was found impractical to use it on the main business streets. The machine was operated between the hours of 10 p. m. and 6 a. m. each week day. It is stated that during the wet season it was necessary to use flushing service as the sweeper did not clean the street of mud The machine traveled 21 miles per day.

Some of the provisions of the specifications for the street sweeping contract are as follows:

The work to be done under these specifications is to clean paved streets in the City of Los Angeles with power-driven street sweepers for a period of 1, 2 or 3 years.

The sweepers shall be suction or vacuum pick-up type, or any power-driven type which satisfactorily gathers up the dirt and transports it to a predetermined dumping point. They must be so constructed that their operations will create no nuisance. Before award of the contract the Board of Public Works may require any bidder to operate a sweeper similar to those upon which his bid is based for a period of 30 days upon paved streets in the City of Los Angeles and demonstrate that the sweeper will clean the streets in a manner satisfactory to the Board of Public Works. For this operation for purpose of demonstration the city will furnish all electric power, fuel and oil actually consumed by the sweeper on the work and will pay not to exceed $3.00 per day for each necessary attendant not exceeding two for the operation of the machine while sweeping. Other expenses of the demonstration shall be borne by the bidder.

Within 90 days after the execution of the contract the contractor shall place in operation enough sweepers to sweep 600,000 sq. yd. of pavement in an 8-hour period. The minimum amount of sweeping shall not be less than 1,200,000 sq. yd. per calendar day except when the pavement is wet from fog or rain.

The contractor shall furnish, from time to time as the Board of Public Works shall direct, and within 90 days from and after written notice to do so, as many other additional sweepers as in the judgment of the Board of Public Works may be necessary or convenient to perform the work contemplated by these specifications; provided, no notice to increase the number of sweepers shall be given within 15 months from the termination of the contract.

Each bidder shall describe the equipment upon which his bid is based and shall state the speed of the machine and the width of pavement swept per trip. If the sweeper will not clean from curb face to curb face additional labor and facilities shall be furnished by the contractor sufficient to complete the work. Each sweeper shall have capacity to carry one or more cubic yards of sweepings.

The working periods for sweepers shall be multiples of 8 hours plus an intermission, if desired by the contractor, of not more than 1 hour.

The Board of Public Works shall have the right to designate the time at which the working period for any district served by 1 sweeper shall commence or end, but the districts served by the sweepers and the hours for sweeping shall be so arranged that each sweeper can work at least 16 hours per calendar day on such days as sweeping is performed. The Board of Public Works shall have the right to suspend sweeping on days when, in the opinion of said Board, the pavement is wet from fog or rain. Sweeping shall also be suspended on such portions of streets as are obstructed in such a manner that the sweeper does not have reasonable access to the pavement.

The Board of Public Works may from time to time, as in its judgment the public need and due convenience require, designate, change, deduct or add paved streets (as well in the matter of the width as the length thereof), which shall be swept by each sweeper, together with the frequency of such sweeping. The driver of each sweeper shall make out a daily report showing streets and portions of streets by blocks swept by him. These reports shall be mailed or delivered to the City Engineer.

Each sweeper shall be kept and maintained in good condition by the contractor. Whenever it is determined by the Board of Public Works that any sweeper, due to unfit condition, does poor work or creates nuisance payments for its services shall be suspended until it is satisfactorily repaired.

Sweepers shall be kept neatly painted and free from advertising matter, and shall have on both sides of same the name of the contractor in letters not less than 3 in. high. All of said sweepers shall be numbered consecutively, and such number shall also be painted on the sides thereof in figures and not less than 3 in. high.

The contractor shall operate and maintain all sweepers and shall furnish competent and properly qualified drivers, other employes, equipment and supplies necessary for such operation and maintenance.

Each driver shall operate his machine so that it will clean in a thorough and satisfactory manner. If unswept or defectively swept areas are found in any block of any street, other than areas used for dumping sweepings, as hereinafter provided, the amount of the entire area of the street in said block shall be deducted from that of the swept area thereof, and the contractor shall not be paid for the amount so deducted. Sweepers shall be equipped with vehicle recorders which will show a continuous automatic record of the speed of the sweeper for all hours of the day and the total distance covered. The records of the vehicle recorders shall be furnished by the contractor to the city.

Any driver repeatedly performing unsatisfactory work shall, upon written request of the Board of Public Works, be discharged by the contractor and shall not again be employed without permission of said Board.

Sweepings shall be dumped upon the streets at points to be designated by the City's Inspector of sweeping, which said points shall be within the district being swept, and at sufficiently frequent intervals to avoid the necessity for idle running.

The sweepings shall be dumped in a compact pile by the contractor so that they can be conveniently loaded into wagons. The city will then dispose of them.

The unit for measurement of sweeping shall be 1,000 sq. yd., which has been entirely swept and cleaned in a manner satisfactory to the Board of Public Works.

All bidders shall name a price per 1,000 sq. yd. for paved areas swept on the basis of the contract for sweeping, having a duration of one year; also a price per 1,000 sq. yd. for paved areas swept on the basis of the contract for sweeping having a duration of two years; also a price per 1,000 sq. yd. for paved areas swept on the basis of the contract for sweeping having a duration of three years. The city shall have the option of awarding the contract on the basis of any one of the above periods. No change as authorized by these specifications in the number of sweepers required or in the aggregate or location of areas to be swept shall be considered as warrant for a change in or modification of the price per 1,000 sq. yd. bid.

On or about the tenth day of each month the City Engineer will make a statement of the amount of sweeping done in accordance with these specifications during the last preceding month. Payment for the work shown by said statement at the price named in the contract will be made upon demands approved as required by ordinance and charter provisions.

## PREVENTION OF BLEEDING AND SWELLING IN WOOD BLOCK.

Successful tests to prevent the bleeding and swelling of wood block have been conducted by the U. S. Forest Products Laboratory at Madison, Wis. The work the laboratory has done in these subjects is described in the Proceedings of the American Wood Preservers' Convention for 1916. This also contains the essential principles developed in the work on bleeding and swelling. Briefly, the idea is to preferably use green timber, and give it a thorough steaming treatment. This is followed by a vacuum to remove excess water and air from the wood. Without breaking the vacuum the oil is run into the cylinder and pressure applied very gradually. The pressure is kept as low as possible during the oil pressure period. A moderate pressure drawn out for a long time gives more uniform penetrations and the oil is better distributed throughout the charge than where high pressures for a short time are used. After the required amount of oil has been injected into the blocks a final vacuum is given. If the tar and creosote mixture is used as a preservative a final steaming and vacuum may be applied to clean off the blocks. Excessive absorptions of oil are one cause of bleeding and, hence, the absorption is specified to be not over 18 lb., and preferably not over 16 lb. per cubic foot.

In case air dry timber is used this also must be steamed if bleeding is to be prevented. Steaming air-dry blocks adds moisture to them and makes them sufficiently resistant to the absorption of oil so that a vacuum may safely be applied before the oil is admitted to the cylinder.

# METHODS OF MARYLAND ROADS COMMISSION FOR PREVENTING EROSION OF ROAD SHOULDERS AND SLOPES.

Various methods are used for preventing the erosion of road shoulders and slopes. The particular system employed, of course, depends in great measure upon local conditions. In Maryland the State Roads Commission has paid much attention to this subject and has developed a number of systems. We are indebted to Mr. Austin F. Shure, Maintenance Engineer of the Highway Commission, for the illustrations and descriptions of the methods used in Maryland.

Figure 1 shows the way the sides of a sandy fill are protected from wash by logs and brush, held in place by stakes and sliding earth. This method gives very satisfactory results. In Southern Maryland where the soil is of a light sandy or gravelly nature this method has been used quite extensively.

Brush has been employed in many places for preventing shoulder wash as well as the washing of the slopes, particularly in the light soil of Southern Maryland.

This crude method is adapted to many localities on account of its being so inexpensive; in fact it answers the purpose in some localities where the most expensive methods fail.

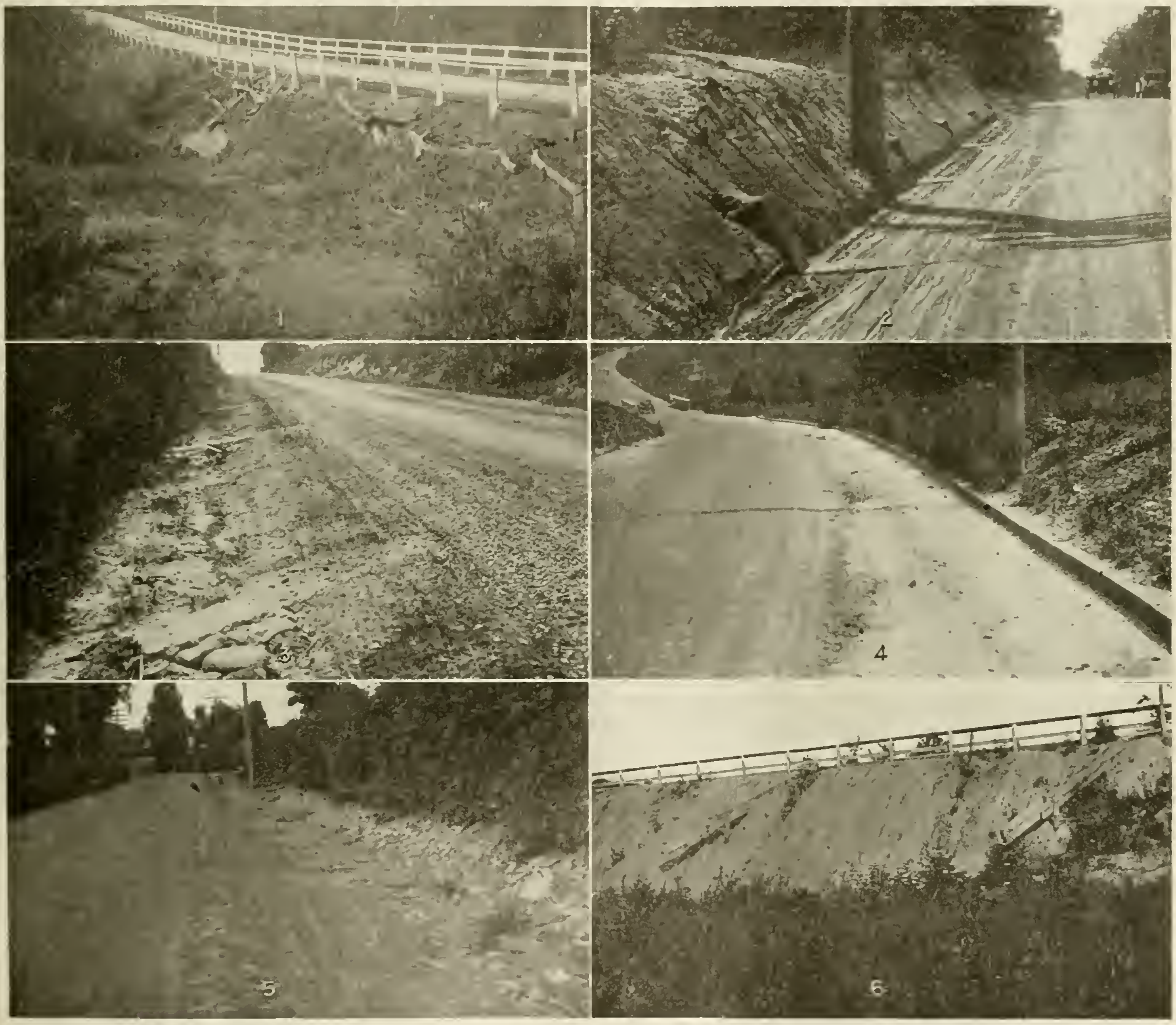
The wooden breaker used on a gravelly clay hillside is shown in Fig. 2. These particular breakers are made of discarded 10-in. bridge timbers. As a rule, however, the wooden breaker is made of 2-in. plank, and in places rough logs have been used. The spacing and depth depends upon the kind of soil and the grade. As a rule they are spaced from 10 to 30 ft. apart and placed from 1 to 2½ ft. deep.

The wooden breaker is the cheapest and most satisfactory breaker in use. The first cost is slight and they can be easily repaired. As a preventative against wash they will do all that can be expected of any breaker.

Figure 3 shows the concrete breaker in use in a light clay soil. This is the first type of breaker ever used by the state. While it answers the same purpose as the wooden breaker it is much more expensive to construct and if washed out it cannot be repaired. Unless it is placed in a very satisfactory manner it will quite often be a failure. The wooden breaker has taken the place of this kind of breaker construction.

The concrete shoulder and gutter type is shown in Fig. 4. There are hillsides where either the volume of water is so great or the soil is of such a character that breakers or other simple and cheap methods of shoulder protection are unsatisfactory and in such places the concrete shoulder and gutter has been used.

The concrete slab is from 4 to 6 in. thick, bound to the edge of the surfacing and built with a curb or shoulder along the outer edge to prevent water from reaching the outside and undermining.



Figs. 1-6—Methods of Maryland Road Commission for Preventing Erosion of Road Shoulders and Slopes.

A cobble shoulder and gutter is shown in Fig. 5. This type of shoulder protection is the most permanent of any in use, although the most expensive. While lots of rough cobble work, built out of field stone, has been done on many roads on the western shore of Maryland, very little shoulder protection of such an expensive type as shown here has been done in the state except on the roads near the Baltimore city limits, where it is used as a protection against wear and not wash.

The latest and most satisfactory method in use as a preventative against the washing of slopes on heavy fills of a light soil is shown in Fig. 6. As shown in the detail view, a wooden shoulder or curb, built of 2 and 3-in. plank, extends along the outer edge of shoulder. Wooden breakers are placed at various points to prevent washing and undermining of this wooden curb, also in front of chute to divert the water into it. A plank is laid flat in front of chute to prevent the water from getting under the end. The chute is placed at an angle of probably 60° with the roadway and spaced from 25 to 100 ft. apart. The length of the chute depends of course upon the height of the fill. Rough lumber is used for this work. Material from 1 to 3 in. in thickness is used.

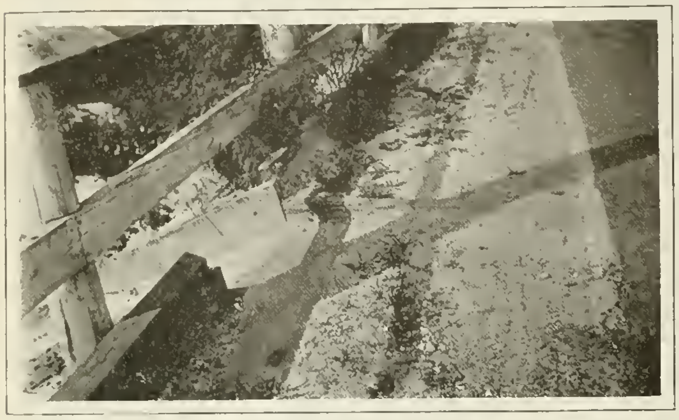


Fig. 7—Road End of Flume.

The cost of this construction is small and at this particular location, on the Belair road not far from the city limits, since the chutes were built in the spring of 1915, they have saved damages from washing which would have amounted to hundreds of dollars.

## EXPERIENCE OF GLASGOW, SCOTLAND, WITH MOTOR STREET SWEEPING MACHINES.

A marked saving in the cost of street cleaning has been effected by the city of Glasgow, Scotland, by the use of motor street sweeping machines. This city has a population of 1,075,000. Its area is 30 square miles and it has 475 miles of streets, most of which are paved with whin or granite blocks; comparatively few streets are smooth surfaced. The mileage also includes a number of macadam roads.

The first mechanically propelled street sweeper of the city started out on Sept. 11, 1912. Since then the number has been increased from time to time until at present the Street Cleaning Department owns 12 machines as follows: Six 18 h.p. of the Lacre Motor Co., Letchworth, England; five 12 h.p. of M. Laffly, Boulogne-Sur-Seine, France, and one 16-18 h.p. of Thomas Green & Sons, Leeds, England.

All the machines are driven by live axle, with the exception of the "Lacre" vehicles, which are chain-driven. All are fitted with rubber tires. The length of the brushes varies from 6 ft. to 7 ft. 2 in., and the actual width swept ranges from 4 ft. 10½ in. to 5 ft. 4½ in. In the case of the Laffly machines the brush is all in one piece (7 ft. 2 in. in length), but in the other types it is made up of segments measuring approximately 16 in. in length. With one exception the machines are equipped with water tanks having a capacity of 80 to 150 gal., from which the water is sprayed under pressure by means of atomizers. The vehicles also are fitted with "cabs" and adjustable windscreens to protect the driver during inclement weather. The experience of Glasgow with these machines is given by Mr. W. Greig, city cleaning superintendent, in a paper presented at the recent annual convention of British Cleaning Superintendents. The matter in this article has been taken from Mr. Greig's paper.

When the introduction of mechanically driven vehicles in place of horse-drawn vehicles was under consideration in Glasgow, the two points which had to be carefully borne in mind were "economy" and "efficiency." These are vital factors—not only in cleansing work, but in all work.

As regards economy, it is recognized that the most profitable work for petrol-driven commercial vehicles is that which involves (1) heavy loads; (2) long journeys; and (3) few stoppages—as short as possible. In cleansing work, motor street-sweeping machines approach most nearly to these ideal conditions.

The journeys are long, the stoppages few and short, whilst the load—the area swept in this case—is greater than in horse-drawn machines, and this should be the greatest possible consistent with speedy working, taking into consideration traffic conditions, running costs, and wear and tear of machines. It is not surprising, therefore, to find that the unanimous opinion of those who have used motor sweeping machines is that they are, from an economical point of view, a pronounced success.

As to efficiency, the general consensus of opinion is that motor street-sweeping machines do the work of sweeping quite as well as—possibly rather better than—horse-drawn sweeping machines. There may be superintendents and others who hold the view that horse-drawn machines do the work better. This is assuming, of course, that the motor sweeper is operating under good working conditions. It is the case that the motor sweeping machine, when the brushes are nearly worn out, may not give as good results during the last half shift when the brush is in reality too short for satisfactory work. This is due to the fact that the first half shift of the last day's work has worn the brush to that point. It must be borne in mind that a motor sweeper traveling over six miles per hour wears out the brush in a much shorter time than a horse-drawn machine, and therefore a half shift in a motor sweeper makes an appreciable difference in a brush, whereas in a horse-drawn machine it is insignificant.

This is one of the few points in which the actual conditions suit the horse-drawn machine better than its rival and enable it to show in a favorable light—it sweeps well to the end of the line of the brush. But this adverse criticism of the motor vehicle only applies to machines working during the night, or at a considerable distance from the depot during the day. If working during the day within reasonable distance from the depot, the worn-out brush can be taken out and replaced. With machines working during the night, or at a considerable distance from the depot during the day, the unsatisfactory work can be reduced to a minimum by working the machines in teams of three or four, utilizing the machine with the shortest brush to perform the first stroke throughout the sweeping operations.

A special feature of the motor sweeper which is worthy of mention is the water tank and atomizer. In sweeping operations during dry weather it was formerly necessary to water the streets in advance of the machine. By the introduction of the water-spraying apparatus on the motor sweeper the time of the horse and man with the watering cart is saved. The state of the surface of the streets is frequently such that smooth-paved streets require watering, whereas streets laid with setts do not need damping. Under these conditions the atomizer shows to advantage. The only difficulty experienced with the spraying apparatus is that it chokes readily with glut, or fine dust or grit, and consequently requires constant inspection and cleaning. In fact, in Glasgow, and some other places, it has been necessary to increase the mesh to meet this objection, at the sacrifice of extra time lost in filling the tank more frequently.

WORKING COSTS OF MOTOR SWEEPING MACHINES FOR YEAR ENDED MAY 31, 1916.

| | |
|---|---|
| Time— | |
| Working days | 1,895 |
| Actually sweeping, hours | 14,846 |
| Average number of hours sweeping per day | 7.83 |

| | |
|---|---|
| Total distance traveled to and from sweeping points | 8,330 |
| Mileage swept, total | 89,393 |
| Mileage swept per day, average | 47.17 |
| Mileage swept per hour, average | 6.02 |
| Area swept, sq yd., total | 275,814,954 |
| Area swept, sq. yd., daily average | 145,530 |
| Area swept, sq. yd., per hour | 18,578 |
| Motor spirit— | |
| Total quantity, gal | 9,811 |
| Total cost | $2,846 |
| Miles per gallon, including traveling | 9.96 |
| Miles per gallon, less traveling | 9.11 |
| Cost per mile, including traveling, ct | 2.88 |
| Cost per mile, less traveling, ct | 3.14 |
| Drivers' wages | $2,904 |
| Repairs, cleaning and supervision | 2,454 |
| Motor spirits | 2,847 |
| Oil, grease and sundries | 438 |
| Brushes, including cost of fitting | 3,853 |
| Tires, upkeep of | 661 |
| Insurance | 372 |
| Depreciation (20 per cent per annum) | 3,364 |
| | $.......... |
| Cost per 1,000 sq. yd. swept, including repairs, ct | 6.1 |
| Cost of brushes per 1,000 sq. yd., swept, including repairs, ct. | 1.42 |
| Saving compared with horse-drawn machine | $6,420 |

Another advantage of considerable value to be obtained from the use of motor sweeping machines may be mentioned here. It is the working of these machines in double shifts. In large towns, where much sweeping falls to be done, and traffic and other conditions permit of its being partly performed during the day, the saving to be effected is too obvious to require further comment. That is, of course, provided always that day cleansing is approved.

The amount of sweeping done by a horse-drawn machine in Glasgow is approximately 17 miles of track. In English towns this length is generally given as about 12 miles.

To get the best work out of a motor sweeping machine it should be worked on long stretches, with as few turns as possible. This entails the working in teams of three or four machines, according to the width of streets to be swept, in order to allow the work of gathering and removal to proceed expeditiously. Another advantage is an appreciable saving in front tires. The turnings are invariably in the shortest radius, and when frequent the grinding action is very detrimental to the tires.

It is essential that the mechanical parts of the machine should be kept in the best of order. An annual overhaul, even if no fault discloses itself, is to be recommended. There also should be at least one spare machine in a fleet of ten to twelve machines.

The drivers should be selected with the greatest discrimination with regard to skill and care and interest in their work. During war time this is difficult—in fact, impossible—and in Glasgow the results are reflected in the loss of working days and the repairs bill. An alert and intelligent foreman can assist the work of exercising close supervision, planning of work and judgment of conditions from night to night. Weather conditions vary greatly, thus quickly affecting the state of the surface of the streets. This in turn determines the pressure of the brush on which, to a large extent, the petrol consumption, the life of the brush, and other wear and tear of the machine depend. A careless foreman or unobservant driver would negligently keep the brush at the same pressure on the surface of a street that is hard and dry, as for one of a pasty nature. Regulation of pressure is absolutely necessary in the interests of economy.

## COST OF TESTING ROAD MATERIALS.

The Bureau of Tests of the State Highway Department of New York is divided into three divisions: a physical testing laboratory, which makes all field examinations, surveys and laboratory tests of stone, gravel, slag, cement, sand and concrete; a chemical laboratory, which samples all asphalts, tars, paints, oils, brick, etc., and an office of record, which compiles and tabulates records of tests of both laboratories. Table I, from the recently issued annual report of Mr. H. Eltinge Breed, First Deputy Highway Commissioner in charge of the Department of Construction, shows the cost per sample in 1915 of testing the different kinds and classes of material.

TABLE I.—COST OF TESTING ROAD MATERIAL BY NEW YORK STATE HIGHWAY DEPARTMENT.

| Distribution. | * 1,748 tests. Cost per test. | Total. | Brick. 269 tests. Cost per test | Total. | Cement. 867 tests. Cost per test. | Total. | Concrete cubes. 1,441 tests. Cost per test. | Total. | Sand and gravel. 973 tests. Cost per test | Total. | Stone. 947 tests. Cost per test. | Total. | Field work special. | Miscellaneous. | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Laboratory work... | $3.36 | $5,872.00 | $5.13 | $1,380.00 | $3.06 | $2,649.78 | $0.49 | $ 713.84 | $2.80 | $2,728.09 | $1.88 | $1,781.34 | ......... | $ 600.00 | $15,725.05 |
| Field work insp'ct'n | 2.67 | 4,665.48 | ..... | ......... | 7.44 | 6,454.56 | ..... | ......... | ..... | ......... | ..... | ......... | $4,582.58 | ......... | 15,702.62 |
| Office work........ | .80 | 1,394.54 | 2.57 | 691.59 | .97 | 840.95 | .30 | 430.13 | 1.26 | 1,221.72 | .91 | 864.88 | ......... | 1,883.82 | 7,327.63 |
| Totals .......... | $6.83 | $11,932.02 | $7.70 | $2,071.59 | $11.47 | $9,945.29 | $0.79 | $1,143.97 | $4.06 | $3,949.81 | $2.79 | $2,646.22 | $4,582.58 | $2,483.82 | $38,755.30 |

*Analyses, oils and asphalts, asphalt blocks, paints, etc.

## MAINTENANCE COST OF BITUMINOUS MACADAM AND BITUMINOUS CONCRETE AT PORTLAND, ME.

Several sections of the state highway system of Maine lie within the city limits of Portland. These sections are maintained by the city. In the recently issued annual report of Bion Bradbury, Jr., Commissioner of Public Works, the accompanying data on this work are given. The first section was constructed in 1908 on Danforth and Vaughan Sts., between St. John and Bowdoin Sts. This was a bituminous macadam, having a total length of 2,879 lin. ft. The total area was 8,657 sq. yd., and the total cost was $9,746, or $1.13 per sq. yd. Section 2, covering 2,687 lin. ft. of Vaughan St., between Bowdoin and Congress Sts., was laid in 1909. The total area is 8,807 sq. yd., and the total cost was $9,068, or $1.03 per sq. yd. This section is bituminous concrete. Section 3 also is bituminous concrete. It covers 1,702 lin. ft. of Cumberland Ave., between High and Elm Sts. The total yardage is 6,398 and the total cost was $8,405, or $1.31 per sq. yd. The cost of maintaining these sections has been as follows:

| Date. | Repairs. | Surface treatment. | Total maintenance. | Maintenance per sq. yd. |
|---|---|---|---|---|
| SECTION 1.—BITUMINOUS MACADAM. | | | | |
| 1909 | $ 90.00 | ....... | $ 90.00 | $0.0104 |
| 1910 | 293.12 | $306.88 | 600.00 | 0.0691 |
| 1911 | 69.50 | 246.04 | 315.54 | 0.0363 |
| 1912 | 72.38 | 157.77 | 230.15 | 0.0266 |
| 1913 | 95.76 | 96.96 | 192.72 | 0.0223 |
| 1914 | 98.13 | 100.58 | 198.71 | 0.0229 |
| 1915 | 60.87 | 126.90 | 187.77 | 0.0217 |
| SECTION 2.—BITUMINOUS CONCRETE. | | | | |
| 1910 | $ 332.67 | ....... | $ 332.67 | $0.0378 |
| 1911 | 99.86 | $406.75 | 506.61 | 0.0575 |
| 1912 | 1,340.54 | 66.35 | 1,406.89 | 0.1597 |
| 1913 | 1,055.03 | 37.31 | 1,092.34 | 0.1240 |
| 1914 | 98.02 | 152.07 | 250.09 | 0.0284 |
| 1915 | 50.40 | 208.49 | 258.89 | 0.0294 |
| SECTION 3.—BITUMINOUS CONCRETE. | | | | |
| 1911 | $ 104.98 | $447.28 | $ 552.26 | $0.0863 |
| 1912 | 449.38 | ....... | 449.38 | 0.0702 |
| 1913 | 761.41 | ....... | 761.41 | 0.1190 |
| 1914 | 312.64 | 165.15 | 477.79 | 0.0747 |
| 1915 | 292.78 | 113.51 | 406.29 | 0.0635 |

## NEW YORK STATE ROAD COSTS IN 1915.

During 1915 the Commission of Highways of New York State placed 1,073 miles of road under contract. Of this total 381 miles are of waterbound macadam; 176 miles of waterbound macadam, surface treatment; 347 miles of bituminous macadam, penetration method; 2.2 miles of bituminous macadam, mixed method; 113 miles of cement concrete pavement; 31 miles of brick, and 23 miles of all other types. The following data on the cost of construction for the different types of pavement are taken from the recently issued report of H. Eltinge Breed, First Deputy Commissioner in charge of the Department of Construction. The figures were obtained by taking those pavements which total 6 in. in thickness and were included between No. 1 and No. 1025:

WATERBOUND MACADAM.

| | |
|---|---|
| Cost per square yard of pavement only | $ 0.648 |
| Cost per mile of 16-26 ft. highway | 10,250 |

The cost per square yard was obtained from 434 values and the cost per mile from 419 values.

BITUMINOUS MACADAM.

| | |
|---|---|
| Cost per square yard of pavement only | $ 0.871 |
| Cost per mile of 16-26 ft. highway | 12,970 |

Both of these items were obtained from the average of 134 highways.

FIRST CLASS CONCRETE, 6 IN. THICK.

| | |
|---|---|
| Cost per square yard of pavement only | $ 1.121 |
| Cost per mile of 16-26 ft. highway | 15,320 |

Both of these items were obtained from an average of 20 highways.

BRICK PAVEMENT ON 5-IN. CONCRETE FOUNDATION.

| | |
|---|---|
| Cost per square yard of pavement only | $ 2.015 |
| Cost per mile of 16-26 ft. highway | 25,750 |

These were obtained from an average of 23 highways.

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## NOTES ON THE PRINCIPLES GOVERNING THE DESIGN OF THE GRAVEL AND MACADAM HIGHWAYS OF THE PHILIPPINE ISLANDS.

Contributed by J. L. Harrison, Acting Supervising Engineer, Iloilo Iloilo, P. I.

In the Philippine Islands the first step in the improvement of an old road, or in the construction of a new road, is the determination of its justifiable cost as computed on the basis of the traffic which the improved road is expected to carry. If the route is one that has been officially selected for improvement and placed on the regular building program, the annual traffic census will have provided all of the data necessary. If not on the regular program, a special census must be taken.

If the work contemplated is the improvement of a well-established road, the taking of special census merely involves counting the vehicles and pedestrians which pass carefully selected stations along the route. Of course an entirely erroneous impression as to the volume of the traffic can be secured either by selecting stations so near to the towns that the traffic is largely local, or by selecting stations so far from the towns that no local traffic is included. Moreover, both daily and seasonal variations in traffic density must be allowed for. An engineer who appreciates the problem will find no difficulty in obtaining satisfactory data, but carelessness in regard to the selection of stations or the choice of improper periods for taking the census will usually render the data secured worse than valueless.

Where the construction of a road over an entirely new route is contemplated the problem is more difficult. Usually there are trails near the new route and more or less parallel to it. These must be investigated and their traffic studied. It may be that water routes are now largely used. The problem then becomes one of determining what part of the traffic going by water would be likely to proceed by land. Often a census of the traffic using a water route will show a considerable percentage that would at once turn to an improved land route.

When the proposed work will not only improve an existing traffic route, but will also connect two previously improved highways, thus opening an improved route between important cities, the problem becomes still more complicated, for there is no relation at all between the traffic originating along a section of improved road and the extra traffic that will pass over it if it becomes a link in a through route. However, as a road system develops the amount of through traffic which may be expected under given conditions becomes pretty well established and a careful estimate of its amount may be added to the local census as a lump sum.

If proper care is used it will almost always be found that the traffic census has shown considerably less traffic than actually passes over the new route. This is perfectly proper, for people will travel oftener and farther over good roads than they will over poor roads. This difference in the volume of the traffic before a road is improved and after it is improved is pretty constant over fairly large areas, and when established by a number of traffic censuses, may be relied on. Therefore, in computing the justifiable cost of an improvement, it is customary to increase the figures derived from the census by a percentage which represents the increase in traffic that has been observed to result from the improvement of other roads in the same region. The justifiable cost is then computed by substitution in the formula,

$$C = \frac{7.2\ n - m}{0.04},$$

in which n equals the daily average number of vehicles of all classes passing over the road, m the annual maintenance of cost per kilometer in pesos, and C the justifiable cost of construction per kilometer, or perhaps more accurately the calculated value of the road to the community. No extra allowance is made for automobiles or other heavy traffic, as all roads built in the past have been cart roads and, except in a few instances, trucks have formed only a small part of the traffic. It is not assumed that the cost of a road will equal its calculated value, but an effort is made to undertake no work which will cost more than the calculated value.

Fig. 1—Candelaria Bridge on Candelaria-Tiaong Road, Torjabas Province.

The next step is the survey. As in other parts of the world so here, the object of the survey is to secure data in regard to the country traversed, the nature of the soil, the drainage, the obstacles to be encountered, the property rights to be adjusted, etc. The road surveys required in the Philippine Islands are not as extensive as the road surveys required by some of the States Highway Departments, largely for the reason that embarrassing claims for damages are seldom entered by abutting land owners, but plan and profile follow much the same lines that are laid down by the better State Highway Departments.

If the traffic census has justified a road, and the survey has been completed, the next step is to determine the exact design of the road, and the question of drainage is one of the first questions which must be considered. It is here that the engineer working in the Philippine Islands first departs from what might be called standard states practice, for he does not take much stock in dry subgrades or worry much about whether his surfacing sheds water like a duck's back or like a sieve. Of course an effort is made to carry off storm water, where this is possible, and to drain such low places as can be drained for a reasonable cost, but all engineers working in the Philippine Islands are confronted by the fact that, unless an undue amount is spent on drainage, most low areas will be ponds during the wet season, and that many of them will be ponds in spite of any amount of drainage. Which leads to the remark that many engineers seem to suppose that in some way all water is to be kept away from a road. One still reads the solemn declaration that a road crust should perform the functions of a roof, though every engineer who has studied the effect of wet weather on road subgrades must know that the amount of water in the subgrade is not only dependent on the amount of water which falls on the road, but also on the position of the water table under the road, and that the road crust has exactly as much influence in determining the location of the water table as has the rural telephone line that runs along the edge of the right of way. If, after a rain, the water table is close to the surface of the ground the subgrade will be over saturated and its carrying capacity correspondingly reduced. Yet even an over-saturated subgrade will carry a considerable load, so the problem of carrying ordinary loads is usually more satisfactorily handled by adjusting the thickness of the metalling to give a satisfactory distribution of traffic loads than by trying to lower the water table.

Fig. 2—Hinigaran-Isabela Road, Occidental Negros Province.

Nor is it always necessary to make all of this adjustment by increasing the thickness of the metalling. Where it is known that a water table at or above the surface of the ground will prevail during a considerable portion of the year a subgrade elevated well above the high water level can usually be employed. It must not be forgotten, however, that if a subgrade is built of clay or loam, capillary attraction will keep it wet for a good many feet above the actual water table and that, as a result, high subgrades do not always give the stability which is expected of them. Thus, because the soils of the Philippine Island favor capillary action, the present tendency in the Philippine Islands is to cut the subgrade to a minimum but increase the depth of the metalling whereaver wet ground is encountered.

The loads carried on the rural roads of the Philippine Islands are comparatively light, and are usually carried on two-wheeled carts. These carts, with their loads, usually weigh about a ton. The law regulates the width of tire to a minimum of 2½ in. In most parts of the Islands trucks are not common and the writer believes that the low cost of local transportation, coupled with the high cost of imported gasoline, makes it unlikely that trucks will become a very large factor in the general road design of this country. Still there are a few provinces where trucks are common and the fact that the number in use has increased rather steadily during the past few years leads many engineers to believe that trucks will soon become as large a factor in the traffic of the Philippine Islands as they are in the traffic of other parts of the world.

However this may be, most of the roads now being built are cart roads and their design presents this general problem: Given a clay or loam subgrade that will, in all probability, be saturated during most of the rainy season (generally six months out of the year) and that may be under water for periods of a week or more each year, what thickness of metalling will be needed to carry 1-ton loaded carts? Upon the answer to this question depends the success of all road building operations.

The answer is almost as simple as the problem itself. Ordinary saturated soils can be depended on to carry safely about a thousand pounds to the square foot. Even when below the level of the water table, if they have been properly compacted by rolling, they will carry this amount. A cart weighing a ton throws 1,000 lb. of load onto each wheel. As this load is being moved over a somewhat uneven surface the effect on the metalling partakes more of the nature of a suddenly applied load than of a dead load. Therefore instead of a dead load of 1,000 lb. per wheel, an effective load of 2,000 lb. per wheel must be allowed for.

If it is assumed that loads are transmitted through the metalling at an angle of 45° from the point of application, the load transmitted by a 3-in. tire will be applied on an area of about 150 sq. in. of subgrade when transmitted through 6 in. of surfacing, about 250 sq. in. when transmitted through an 8-in. surfacing, and about 390 sq. in. when transmitted through a 10-in. surfacing. From this it is clear at a glance that the ordinary cart road, if it is expected to carry 1-ton carts and must be built over wet ground, should have a surfacing a little over 8 in. thick, and it may be added that the roads of the Philippine Islands which have 8 in. of metalling have stood up very well indeed, even where the subgrade has been wet for long periods.

Of course, where a well-drained subgrade can be depended on 6 in. of metalling is sufficient and over sand 4 in. of metalling has often given satisfaction. On the other hand places are occasionally found where even 10 in. of metalling is none too much. In every case the determining factor is the sub-grade, and not the metalling.

It has been said, and this point should be remembered, that the roads which have been built in the Philippine Islands are cart roads. Heavy truck traffic would require very much heavier metalling or the construction of subgrades that could be depended on to support more weight that a wet Philippine subgrade will support when protected by an ordinary thickness of metalling. Thus suppose 5-ton trucks (truck and load 8 tons) had to be provided for under the above assumptions. A 5-ton truck under a very slight overload will throw 3 tons of weight onto each of the rear wheels. Running at a speed of 10 miles an hour, not an uncommon speed, and equipped with steel tires, the loads delivered to the metalling by such a machine cannot be considered as simple dead loads, but must be dealt with as impact loads. This is rather an extreme assumption, but any one who cares to observe the "pound" of a 5-ton truck as the wheels drop off of the slight projections which exist on the surface of every gravel or macadam road, will soon conclude that even though it should ultimately be proved that full impact loads are not developed, there can be no doubt that the loads actually delivered to the metalling partake very largely of the nature of an impact load. This being the case, the rear wheels of a 5-ton truck must be constantly delivering to the metalling, not 3-ton dead levels, but blows which approach 12 tons. If the truck is traveling over a 6-in. pavement, the subgrade must, therefore, be receiving shocks that reach an intensity of well over 10 tons per square foot. Now, no

Fig. 3—Manila North Road at Km. 50.

Low subgrades are used even in the rice region. During at least four months of every year water stands in these rice fields.

earth or clay subgrade will stand any such loads as this even when it is dry. The stone in the road crust will be driven down into the subgrade and the surface of the road will begin to show ruts, though the stone of which the crust is composed shows no unusual wear.

To carry heavy trucks either the road must be made very deep or the subgrade kept very dry. Because of the excessive rainfall of the Philippine Islands, the latter method cannot be followed here. Parenthetically it might be remarked that much of the trouble which has been encountered in building rural highways in the United States is due to a tendency to base highway design on the carrying capacity of dry soils and to overlook the fact that no matter what sort of a road crust is used, a protracted rain will soften the subgrade. As all loads are actually carried by the subgrade, and as the metalling is placed for the purpose of distributing the load on the subgrade, and protecting the subgrade from such damage as would otherwise be caused by the traffic, this tendency to base highway design on the maximum instead of the minimum strength of the subgrade has, in many instances, proved disastrous.

The proper thickness of the metalling having been settled, there remain such questions as width of metalling, width of shoulders, slopes to ditches, maximum grade, minimum radius of curvature, etc., which are settled by highway engineers in the Philippine Islands just about as they are settled by highway engineers in other parts of the world. The tendency of the highway engineers working in the Philippine Islands is rather strongly toward the elimination of curves, but property owners in the United States would, in all probability, be so much less liberal than they are in this country that the extensive rectifications of alignment that have been undertaken in many parts of the Philippine Islands would there lead to endless litigation and prohibitive costs. At present a 5 per cent grade is nominally the maximum allowed, but the extra cost of construction sometimes makes it advisable to use steeper grades. Similarly a minimum radius of curvature has been adopted, and a definite effort is made to keep above this minimum, but where it becomes a question of a shorter radius or a serious increase in cost the minimum is waived.

One often reads statements to the effect that the best stone is the cheapest in the long run, by which it is intended to imply that for road metalling the hardest and toughest stone available should always be used. It is hard to see any logical basis for such an idea, unless it be that the American custom of building roads and then abandoning them to the tender mercies of traffic and weather until they have been so nearly destroyed as to require rebuilding, has led engineers to wish for a stone that could withstand the exigencies of severe traffic conditions a little longer than the stone commonly used. However this may be, wherever there is constant and efficient caminero maintenance the hardest and toughest stone is not always the best for road surfacing.

In the first place the cost should be considered. Engineers differ as to what the actual cost of a road really is. This difference in opinion is probably due to different methods of financing construction, but where construction is paid for out of current revenues derived largely from direct taxation there can be little question that the true cost is the "out of pocket" cost and no more. Therefore in the Philippine Islands engineers are justified in their practice of adding together the construction cost, the maintenance cost over a period of years, and the cost of such resurfacing as will probably be necessary during the period under consideration and calling this the total cost for the period in question. When this is done it will frequently develop that the hardest stone is by no means the cheapest.

Moreover even when the hardest stone seems to be the cheapest it is not always the proper stone to use. Recently the writer went over a piece of road now six years old, that is surfaced with the hardest and toughest stone that he has ever seen. On the city streets of Iloilo this same stone has been very satisfactory, but on this country road it has had so little traffic that it is still sharp and so hard on the feet of unshod animals that after only one or two trips over it, they must be sent back to the fields until their hoofs grown out again. Now, a softer stone might have shown a slightly higher average annual cost than this stone shows, but it would have been much more satisfactory to everyone using the road.

Another matter to be considered is whether a stone will provide enough binder to keep the road smooth. If the rainfall is heavy this is a serious question on light traffic roads. For such roads it is much better to use a fairly soft gravel than it is to use a hard broken stone. In other words, a gravel or macadam road must wear down fast enough to provide for such material as is washed or blown from the surface or else the individual stone will be exposed and torn out by the traffic with the result that a rough surface is produced and the average rate of deterioration greatly increased.

Another matter of considerable importance is the question as to how well the dust from a stone will hold water. Stones high in free quartz make poor road metalling for roads subjected to a long dry season because the stone dust does not hold enough moisture to enable it to retain its binding qualities. On the other hand, where a road must be built over very wet ground a stone high in quartz may be used to advantage. Where a road must endure an annual dry season, the selection of a stone which produces a dust that holds moisture well, will add considerably to the life of the metalling.

These points having been settled, the design of the cross section of a road is a comparatively simple matter. The actual design is not of special interest, but it may be worth while to note that there is a decided tendency to flatten the crown of all gravel and macadam roads built in the Philippine Islands. By so doing the tendency of the traffic to follow one beaten track is distinctly lessened. It used to be supposed that flattening the crown would permit more water to soak through the metalling into the subgrade, but as engineers have learned that their subgrades were saturated in any case the prejudice against flat crowns has diminished.

On the whole the design of the highways built in the Philippine Islands is not very different from the design of the highways built in other parts of the world, but the heavy rainfall of these islands has forced engineers to face the fact that a highway is essentially a means of transmitting heavy loads to an unstable subgrade. This has led to an effort to base the design of all highways on the supporting power of the subgrade, rather than on the ease of traveling over these highways. It is felt that this effort on the part of the engineers in the Philippine Islands is along the right line and that it will lead to more and more efficient design. When engineers working in the United States also give more attention to the subgrade and to the proper support of the loads which their roads must carry, it is thought that American highway design will be materially improved and that pavement failures will be less frequent.

## ROAD SUBSURFACE DRAINAGE IN CLAY CUT.

An interesting method of providing subdrainage for a road constructed through a clay cut was described by Mr. Charles J. Bennett, state highway commissioner of Connecticut, in a lecture this spring in the Graduate Course in Highway Engineering, Columbia University. The road was constructed in Connecticut on what is known as "Branford Hill," where a heavy cut varying from 6 to 12 ft. was made through a clay soil consisting of what is known in that section as "laminated" clay, that is clay deposited in layers of practically uniform thickness separated by fine sand joints. The material in this particular cut was so hard in dry weather that it was difficult for men to remove it with picks and it resisted the action of a steam shovel materially. During heavy summer rains, the material became saturated and muddy and the road leading to the steam shovel was corduroyed with old ties. Under the action of the heavily loaded clay wagons, these ties were forced into the wet clay subsoil for a depth of 2 to 3 ft. It was evident, therefore, that some radical and finished means of providing subsurface drainage was necessary to prevent any breaking up of the road surface under these abnormal conditions and the following method was employed:

Two side ditches were excavated at the foot of slopes in the cut to a depth of 3 ft. below the finished road grade. On the down hill side, a 6-in. tile was placed in the bottom of this ditch, and on the up-hill side, a tile sufficient to take, not only the subsurface water but also the surface water which fell on the surrounding country and which was led down the slopes into frequent catch basins. The trenches about and above these tile were filled with broken stone, and cross drains laid herringbone fashion were installed beneath the road surface at approximately 50-ft. intervals. On top of this drainage system was constructed a 6-in. concrete road. It is stated that there has been absolutely no trouble from subsurface water.

## COST OF BITULITHIC PAVEMENT ON A ROAD NEAR TACOMA, WASH.

A 2-in, bitulithic pavement on a 5-in. concrete (1:3:6) base has just been laid between Alderton and Orting, under the direction of Mr. David H. White, County Engineer of Pierce County, Tacoma, Wash. The work was done by contract, Washington Paving Co., contractors, at a cost of $1.445 per square yard, distributed thus:

| | Per sq. yd. |
|---|---|
| Subgrade, curb and extras | $0.234* |
| Concrete base | 0.600† |
| Bitulithic top | 0.686† |
| Total | $1.520 |

*On 52,949 sq. yd. of 17-ft. pavement. †On 48,878 sq. yd. of 16-ft. pavement.

The paving is 16 ft. wide and cost $14,390 per mile for 5.33 miles, inclusive of a 5-year guarantee. The net price of cement was $1.90 per barrel, wages of common laborers were $2.50, teams $5 per day of 8 hours.

The quantities of material in the 2-in. bitulithic top were approximately as follows:

0.046 cu. yd. crushed rock.
0.024 cu. yd. sand.
0.01 ton bitulithic cement.

About 1,000 sq. yds. of the top were laid per day of actual working time, but there were many delays. A force of 10 men, 1 superintendent and a team operated the bitulithic, screening, heating and mixing plant, which was a 1-car asphalt plant. In placing the bitulithic top and seal coat the force was 12 men, a foreman and a rollerman on a 10-ton roller. Hauling the top material required 3 to 13 teams, depending on length of haul, the average haul being 1.35 miles.

## 8,400,000 SQ. YDS. OF CONCRETE PAVEMENT.

Figures recently furnished by the Road Bureau of the Portland Cement Association, indicate that in five states contracts have so far been awarded this year for 1,000,000 or more square yards of concrete pavement. The states and figures are as follows:

| | Sq. yd. |
|---|---|
| Illinois | 1,412,789 |
| Ohio | 1,391,430 |
| Indiana | 1,342,095 |
| New York | 1,150,304 |
| Iowa | 1,000,291 |

Michigan, Wisconsin, California and Texas are making good strides toward the million mark, as indicated by the following figures, although it should be mentioned that the records of California were not complete when totals were made up.

| | Sq. yd. |
|---|---|
| Michigan | 606,112 |
| Wisconsin | 546,203 |
| California | 448,749 |
| Texas | 530,470 |

It is interesting to know that most of the yardage in Iowa is for city streets, while the greater portion of the yardage in other states is for country highways.

## COST OF ROCMAC AT SPRINGFIELD, MASS.

During the late fall of 1915 the city of Springfield, Mass., constructed 3,153 sq. yd. of rocmac, the work being done by city forces under the direction of F. H. Clark, Superintendent Department of Streets and Engineering. The rocmac was 3 in. thick and was placed on top of an old, wornout macadam pavement. On one of the streets there was a 12 per cent grade; on the other a 9.4 per cent grade. This spring the work was covered with ¼ gal. of Tarvia B per square yard and sanded. The costs were as follows:

MAPLE STREET, 2,563 SQ. YD.

| | | Per sq. yd. |
|---|---|---|
| Grading | $ 279.86 | $0.109 |
| Rocmac | 1,861.49 | .726 |
| Gutters | 291.20 | .113 |
| Tarvia B | 23.92 | .009 |
| Total | | $0.957 |

GRADE 9.4 PER CENT, CHESTNUT ST., 590 SQ. YD.

| | | Per sq. yd. |
|---|---|---|
| Grading | $ 107.90 | $0.183 |
| Resetting curb | 279 76 | .474 |
| Taking out tree | 7.96 | .013 |
| Rocmac | 306.38 | .519 |
| Gutters | 52.25 | .088 |
| Total | | $1.277 |

The prevailing wages for common labor were $2.25 per 8-hour day. Teams with drivers were paid for at the rate of $5.25 per day.

## STATE RURAL HIGHWAY CONSTRUCTION IN MINNESOTA.

The state rural highways of Minnesota are being constructed at an average cost of $2,867 per mile. The total cost of 50 of these highways, aggregating 1,133.9 miles, will be $3,254,032. The following table from the August Minnesota Highway Journal shows the roads completed and under construction and the costs:

| County— | S. R. H. No. | Length. | Class. | Total cost. | Cost per mile. |
|---|---|---|---|---|---|
| Aitkin | 10A | 20.1 | Surfaced | $ 56,378.86 | $2,805[1] |
| Aitkin | 10B | 19.0 | " | 56,112.67 | 2,953[2] |
| Aitkin | 70 | 64.0 | " | 212,859.82 | 3,326 |
| Beltrami | 9A | 5.5 | " | 14,868.24 | 2,713[2] |
| Beltrami | 9B | 12.73 | " | 23,704.94 | 1,862[2] |
| Beltrami | 9C | 6.5 | " | 15,833.70 | 2,436[3] |
| Beltrami and Kooch | 12 | 45.11 | " | 108,259.31 | 2,399[2] |
| Beltrami | 32 | 33.5 | " | 121,375.00 | 3,623 |
| Beltrami | 62 | 34.81 | " | 149,083.11 | 4,283[2] |
| Blue Earth | 27 | 11.3 | Gravel | 21,773.76 | 1,926[1] |
| Brown | 54 | 29. | " | 57,378.17 | 1,979[2] |
| Carlton | 11 | 28.02 | " | 103,000.00 | 3,675 |
| Cass | 45 | 22.59 | Earth | 62,842.60 | 2,781[4] |
| Cass | 80 | 71.7 | Surfaced | 213,358.97 | 3,003[4] |
| Cass | 81 | 45.65 | " | 74,342.14 | 1,629[4] |
| Cass and Hubbard | 82 | 29.50 | " | 88,021.75 | 2,933 |
| Cass | 83 | 29.25 | " | 73,038.88 | 2,497[2] |
| Hennepin | 26 | 2.99 | Concrete | 51,341.20 | 17,272[1] |
| Hubbard | 9A | 9. | Surfaced | 5,393.71 | 599 |
| Hubbard | 9B | 46.87 | " | 74,667.15 | 1,593 |
| Hubbard | 55 | 10.85 | " | 17,429.04 | 1,606[1] |
| Koochiching | 5 | 23. | Earth | 32,114.46 | 1,396[2] |
| Koochiching | 9 | 75.1 | " | 155,723.74 | 2,074[2] |
| Koochiching | 20 | 21.7 | " | 22,257.14 | 1,025[2] |
| Koochiching | 24 | 52.77 | " | 115,879.21 | 2,196[2] |
| Lincoln | 54 | 20.4 | Gravel | 41,570.65 | 2,038[1] |
| Lyon | 54 | 24.5 | " | 45,785.57 | 1,869[5] |
| Nicollet | 54 | 27.5 | " | 55,392.29 | 2,014 |
| Nicollet | 57 | 12.5 | " | 30,556.26 | 2.445 |
| Pennington | 14 | 21. | Gravel | 47,439.88 | 2,259[1] |
| Pine | 43 | .30. | Earth | 63,819.96 | 2,127[2] |
| Redwood | 22 | 5.75 | Gravel | 7,982.24 | 1,388[1] |
| Redwood | 50 | 6. | " | 11,475.04 | 1,913[4] |
| Redwood | 51 | 22.93 | " | 56,498.68 | 2,464[4] |
| Redwood | 74 | 8. | " | 28,960.00 | 3,620[4] |
| Redwood | 93 | 18.5 | " | 56,548.20 | 3,057[4] |
| St. Louis | 4 | 32.5 | " | 148,095.44 | 4,556[1] |
| Winona | 1 | 6.86 | Concrete | 56,874.64 | 8,290[1] |
| Winona | 2 | 4.35 | " | 30,613.26 | 7,038[1] |
| Winona | 3 | 4.60 | " | 33,518.22 | 7,287[1] |
| Winona | 85 | 27.05 | Brick Macadam | 176,988.10 | 6,543[4] |
| Winona | 86 | 20.85 | " | 110,744.24 | 5,311[4] |
| Winona | 87 | 7.7 | " | 50,641.90 | 6,576[4] |
| Winona | 88 | 7.02 | Gravel | 30,265.00 | 4,311[4] |
| Winona | 89 | 4.4 | " | 19,434.20 | 4,417[4] |
| Winona | 90 | 4.95 | " | 19,833.30 | 4,007 |
| Winona | 95 | 6. | " | 26,118.00 | 4,353[4] |
| Winona | 96 | 10.5 | Gravel Macadam | 51,172.00 | 4,873[4] |
| Yellow Medicine | 36A | 18.5 | Gravel | 54,500.00 | 2,946[4] |
| Yellow Medicine | 36 | 31. | " | 72,167.86 | 2,328[1] |

[1] Final cost. [2] Contract price. [3] Not final. [4] Estimated. [5] Contract and estimated.

## TEST OF CONCRETE CUBES BY NEW YORK STATE HIGHWAY DEPARTMENT.

The making of concrete cubes in the field and the testing of them in the laboratory has proven very valuable in determining more accurately the quality of the concrete used in the work of the State Highway Department of New York. According to the recently issued report of Mr. H. Eltinge Breed, First Deputy Highway Commissioner, 1,444 of these cubes were tested in 1915 by the Bureau of Tests, the average results obtained being as follows:

| Concrete mix. | Average compression, lb. per sq. in. | No. of cubes. |
|---|---|---|
| 1—1½—3 | 3,620 | 796 |
| 1—2½—5 (crushed stone) | 1,935 | 222 |
| 1—2½—5 (gravel) | 1,755 | 200 |
| 1—2½—5 (all cubes) | 1,875 | 474 |
| 1—3½—4<br>1—3—4½ (mostly slag) | 2,140 | 56 |

Cubes showing compression below 3,000 lb. per square inch for 1:1½:3 and 1,800 lb. per square inch for 1:2½:5 are considered below the desirable grade. There were 25.8 per cent of these in 1914 and 10.95 per cent in 1915. All cubes showing a compression below this desirable grade are carefully inspected to try to determine to what the low strength is due. Any of them which show indications of carelessness in the mix are returned to the division office with laboratory comments.

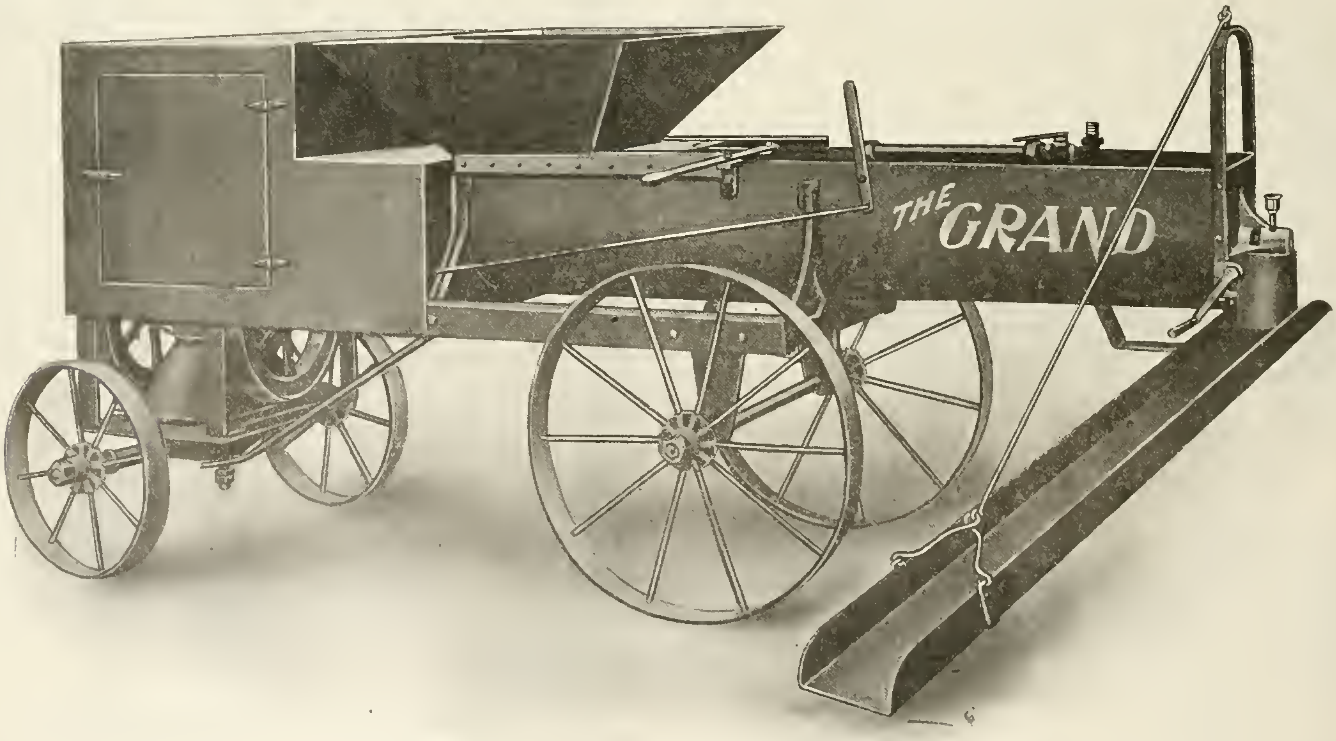
The following is a tabulation of the low cubes during 1915 and reasons which seem to cause the low break, with percentage of the same:

| Cause of low break. | Per cent. |
|---|---|
| Sand dirty, containing loam and also dirt from subgrade | 35.4 |
| Stone or gravel coated | 35.0 |
| Sand too fine | 8.5 |
| Poor quality of stone or gravel | 8.2 |
| Poor manipulation in making cubes | 4.7 |
| Lack of proper mixing | 3.5 |
| Miscellaneous, too wet, etc | 4.7 |

All concrete cubes have heretofore been tested 28 days after casting. This period was chosen because comparative data was available on compression for concrete at this age. During 1915 enough cubes were broken at an age of seven days to give sufficient data to be able in future to judge the quality of the material when broken at this age. Testing at this period will enable the department to correct any faulty condition more promptly. It will still be necessary to test occasional 28-day cubes as a check on the increase in strength.

## GROUT MIXER.

The accompanying illustration shows a special mixer that has been developed by the Hall-Holmes Manufacturing Co., Jackson, Mich., for mixing grout and other slush mixtures, for use in brick pavement construction and for top mixture for concrete pavements, sidewalks, etc. The mixer is equipped with a 2½-H.P. gasoline engine and is mounted on steel trucks with 20-in. wheels in front and 30-in. rear. The mixing paddles are of crucible steel. The charging hopper has two compartments, one for sand and one for cement and the contents are discharged into the mixing trough by pulling a lever. The gate at the discharging end permits the operator to pour a small quality of the grout, or the entire contents of the trough, as he may desire.



Special Mixer for Mixing Grout and Other Slush Mixtures.

## PERSONALS.

Paul F. Kressly of Inglewood, Cal., has been appointed City Engineer of Newport Beach, Cal.

Nelson F. Tift, formerly Mayor of Albany, Ga., has been appointed Superintendent of the Water, Gas and Electric Light Departments of that city.

George F. Weighardt has been appointed assistant water engineer of the city of Baltimore, Md. He formerly was assistant engineer of the Pennsylvania State Water Supply Commission.

R. J. Lockwood, heretofore vice-president and general manager of the New Iberia & Northern R. R., has been appointed vice-president and general manager of the Apalachkola Northern R. R., with headquarters at Port St. Joe, Fla.

Adolph G. Carlson has been appointed Chief Engineer of the Universal Portland Cement Co. Mr. Carlson was formerly Assistant Superintendent of the Syracuse, Ind., plant of the Sandusky Portland Cement Co. He has had to do with the designing of No. 3, 4 and 6 mills of the Universal Portland Cement Co. at Buffington, Ind., and No. 5 mill at Pittsburgh and No. 7 mill at Duluth. He was appointed Mechanical Engineer in 1907. M. S. Humphreys, formerly Superintendent, Mill No. 6, Buffington (Ind.) plant of the Universal Portland Cement Co., has been appointed Assistant Mechanical Engineer at the General Offices in Chicago. Nels Nelson, formerly Superintendent Mill No. 2, at South Chicago, which plant has been dismantled, has been appointed Superintendent Mill No. 6, Buffington (Ind.) plant. J. H. Lendi has been appointed Electrical Engineer at the General Offices in Chicago. Mr. Lendi has been connected with the company for several years in the Engineering Department. A. C. Wilby has been appointed Assistant to President, having been assigned to those duties in April, 1915, after seven years connection with the Sales Department of the company, first as salesman, later as Division Sales Manager.

## OBITUARY.

Authony Walsh of Davenport, Ia., died Aug. 27 in San Francisco, Cal., aged 83 years. Mr. Walsh and his sons built the Rock Island & Southern R. R. in Iowa.

August Johnson, street commissioner of Fargo, N. Dak., for [illegible] years, was caught under a concrete mixer and crushed to death.

Emil Herta, for 30 years Thomas A. Edison's chief mechanical engineer at the West Orange plant, who had worked on many of Edison's important inventions, died Aug. 23 at Orange, N. J. He was 59 years old.

## INDUSTRIAL NOTES.

The Lynchburg Foundry Co., Lynchburg, Va., manufacturers of cast iron pipe and fittings, has opened an export office at 90 Wall St., N. Y.

The Chicago Bridge & Iron Works, Chicago, Ill., has recently opened an office in Jacksonville, Fla., in the Florida Life Bldg., in charge of Mr. Elwood G. Ladd. This office will handle the sales in the states of Georgia, Florida and Alabama.

The American Industrial Commission to France, organized by the American Manufacturers' Export Association, sailed on Aug. 26. The Commission, of which William W. Nichols, assistant to chairman of the Board of Directors of the Allis-Chalmers Co., is chairman, will make a scientific study of industrial conditions. Among the members of the Commission are: John R. MacArthur, of MacArthur Brothers, General Contractors, of New York City; Dr. C. O. Mailloux, Consulting Engineer, New York City; N. F. Hoggson, President of Hoggson Brothers, Inc., Contractors, New York City; Ambrose Swasey, President of Warner & Swasey, Cleveland, O.; George B. Ford, of George B. Post & Sons, Contractors, New York City, and James E. Sague, M. Am. Soc. M. E., Poughkeepsie, N. Y., former Vice-President of the American Locomotive Co.

Water Works and Hydraulics Issue
of
Engineering and Contracting
Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., SEPTEMBER 13, 1916. Number 11.

## WATER REFINING.

A review of practice in deferrization of water is published on another page. This article, in addition to the specific information which it furnishes, suggests thought of a development in water supply for potable purposes which is particularly the product of the present century. This development may be called water refining. Protection of sources of water supply from pollution, purification of polluted water by filtration and disinfection are no longer adequate to produce a tolerable water supply. Such supply to meet the cultivated requirements of the modern water user must be refined. One easily fails to realize the number of refinements called for and practiced until he enumerates them. There are clarifications, decolorization, deodorization, softening, deferrization. To name these processes is sufficient for an understanding by the water works engineer. Their common characteristic is that in no instance is the process one of sanitation. A water that has color or odor or is hard may be absolutely sanitary; it does not, however, satisfy taste and comfort and hence the growing demand for refinement.

## VALUES OF KUTTERS' N FOR DRAINAGE DITCHES.

There are illustrated on another page eight views of drainage ditches. The reader familiar with the reclaimed land areas of the Mississippi Valley will recognize these views as typical. The modern drainage ditch at its best is never the clean lined trapizoid depicted in the engineer's blue prints; at its worst it is a rough banked, vegetation choked, irregular waterway. As a channel for conveying water it is a crude affair. The interest of the ditches illustrated, however, lies in the fact that they have been measured to determine the values they gave for N in Kutters' formula. The value of this factor has been determined for many characters and conditions of channel, but its determination on actual drainage ditches has been rare. Herein lies the interest of the tests described.

## CITY WATER SUPPLY FOR IRRIGATION.

Comment on recent editorials advocating the development of city water supply for irrigation is made in this issue by two interested writers. Both of these writers see difficulties in the way of such an improvement, though the one from Dayton, Ohio, recites with a tone of justifiable pride the fact that the very thing advocated by our editorials was accomplished in that city during the drouth of the past summer. There are without an atom of doubt obstacles to be overcome and ways and means of many sorts to be devised to develop profitable supply of city water for irrigation. But none of these obstacles is insuperable and to think that invention of successful ways and means is beyond the genius of water works management is to defame common sense.

One of our correspondents in this issue says that most of the water supplies with which he has been identified "are considered very precious." They are. It is the time-old tradition to hold city water a treasure to be conserved and not a commodity to be marketed and utilized. Herein is the great obstacle to be overthrown in any undertaking to extend the use of city water for irrigation. Parenthetically, here, the remark is perhaps justified that when water surveys have been undertaken it has been shown conclusively that water has seldom been held too precious to waste. Any development of city water for irrigation involves measures to eliminate waste first of all. Let us consider the city of Chicago as we have in previous editorials. The experts who have studied the water supply of this city assert that of the more than 600,000,000 gal. pumped daily nearly 60 per cent is wasted; only 40 per cent produces revenue though that revenue is $7,000,000 gross per year and enough to meet all costs without deficit. Now 600 million gallons with 60 per cent waste is 360 million gallons wasted per 24 hours, and this is not far from 1,000 acre feet of water. The irrigation engineer knows what can be done with this water in the way of irrigation if the water works engineer requires telling. With this 360 million gallons of waste water utilized, not wasted, what becomes of any claim for Chicago that city water is too precious to use for irrigating gardens and lawns?

Another fear that the water works manager needs to get away from is that of some possible precipitous cloud reaching peak consumption. We know of few arid regions under irrigation where the land is irrigated each day or where all the land taking water is irrigated the same day. Were this the practice there are many irrigation works which would soon be put out of commission. At many irrigation works quite intricate systems of water allotment and distribution are managed with general success. There is no peak load in the sense that there is a peak load in city water supply. There need be no peak load greatly beyond the normal in supplying city water for irrigation. There will be unusual consumption but it need not come as a peak.

The development of city water supply for irrigation involves a comprehensive plan of service. It involves control of waste, education of householders to the advantages and profit of gardens and lawns, devising a system of water allotment and distribution for other than potable uses and co-ordinating all with the capacity of the source of supply and of the plant available. In all that we have said of the development being discussed we have not for a moment thought that it was a simple problem—something to be accomplished merely by multiplying plant and declaring unstinted use of water. We do maintain that there is a big constructive opportunity in the development of city water supply for irrigation.

## EDITORIAL PARAGRAPHS.

One involuntarily associates wood stave water pipe with regions west of the Rocky Mountains. Many New England city water works have in recent years, however, used wood pipe to an extent which would be worthy of exceptional remark were the greater records of the Pacific Coast not at hand for comparison. Incidentally bored log water pipe is still occasionally being unearthed in old New England towns in a good state of preservation after being buried over two hundred years.

Typhoid is described as a disease of defective civilization. The logic is plain. Typhoid results from defective sanitation and defective sanitation means defective civilization.

In so far as typhoid is a water borne disease Mr. George A. Johnson tells us the figures are as follows: "Twenty millions of people in the United States are now being furnished with filtered water at a cost not exceeding $8,000,-

000, or 40 ct. per capita, per year, and in the cities having filtered water supplies the water-borne typhoid has been practically eliminated, as reliable statistics abundantly show. Filtration of the water supplies of the remainder of the urban population of the United States would cost not more than $11,500,000 per year, and reliable statistics show that to do so would, at the very least, save 30,000 typhoid cases and 3,000 deaths each year, equivalent to vital capital in the total sum of $22,500,000 annually, or twice the money cost of prevention."

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The number of organized bodies which keep a watchful eye over the waters of each of our northern states is rarely comprehended by the average water user. In the last report of the Illinois Water Survey the director, Mr. Edward Barton, lists eighteen organizations besides his own which exercise a more or less watchful supervision over the waters and water supplies of the state.

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The water bacteriologist often waxes justly indignant over the apathy and frequently active opposition with which the general public receives his teachings. These faults are not always confined to the unscientific. Professor Sedgwick is fond of telling the story of Liebig, who refused to look through a microscope, refused to believe that one could learn anything by the use of a microscope, cast ridicule on this manner of research and by his influence delayed the development of the germ theory for many years. And Liebig was one of the most distinguished scientists of the nineteenth century. A few years ago when the use of alum in water purification was proposed very many men of scientific training vigorously upheld the newspapers in their attack on drinking "puckered" water.

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## HOUSE CONNECTIONS AS A FACTOR IN INFILTRATION.

To the Editors: In your issue of Aug. 9 I note particularly the article contributed by Mr. W. W. Dixon, entitled "House Connections as a Factor in Infiltration."

The proportion of ground-water infiltration into sewers chargeable to house drains, as they are usually laid, is so great that I have found it wise to emphasize this factor even in preliminary reports on proposed sewerage systems. I know one case where the first 50 house connections more than doubled the flow of ground-water in a system of sewers covering seven miles of streets.

In my preliminary report on the sewerage of Southington, Conn., I said:

> Leaky house-drains form the worst menace to a sewer system in wet territory. They are built from time to time as needed—not synchronously with the sewers—by plumbers good, bad and indifferent, and all too often without adequate municipal control of design and construction. The tightest of street sewers can he flooded with ground-water admitted through defective house-drains, and defective house-drains are much more common than good ones. Before a single connection with the sewer is made, the Borough should enact drastic ordinances controlling connection with and use of the sewers; and these ordinances should be enforced to the letter by an inspector of plumbing, clothed with proper authority, competent, incorruptible and a martinet in the exercise of his functions.

I believe the collection and publication of data on this subject would help greatly in the adoption and enforcement of ordinances that will protect municipal sewer systems from floods of ground-water that they should never receive.

G. Everett Hill,
Vice-President and Chief Engineer.
City Water Disposal Co.

New York, N. Y.
Aug. 18, 1916.

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## CITY WATER SUPPLY FOR IRRIGATION.

To the Editors: The article on saving city water in your issue of Aug. 2, does not apply to Dayton, O. We had no rainfall at all during the latter part of June and the first 30 days of July. In spite of this, the water works handled the load without any sign of shortage or effort to limit the consumption.

Dayton has the direct pumping system on the low service, with standpipes on the high-pressure lines to the hilltops. Our peak load last month climbed to seven times our night rate. We make a fair profit on all water pumped and so are anxious that the water be used. These facts were advertised to the people through the papers with the suggestion that their gardens and lawns be kept green and fresh. Two years ago, before the water works system was overhauled, the water officials had to secure the co-operation of the papers and the police to limit the sprinkling.

Today the gardens, flowers, and lawns inside the city are green, while those where water is not available are dry and parched. Our plant has been built with regard to future growth. It is capable of handling a conflagration on top of our sprinkling load. A good part of our investment has already been made, so the extra load increases the returns. Its desirability, however, should be seriously considered.

The small user who makes our peak load pays 8 ct. a thousand gallons. Our amount of pumping is 12,000,000 gal. per day, with a maximum day of 21,000,000. For argument we will assume that a sprinkling campaign might increase our maximum day 4,000,000 gal., three of which would be pumped between 5 and 8 in the evenings. This would mean an additional peak at our plant of 24,000,000, which would increase our pumping equipment and man requirement by 50 per cent to render our present high type of service.

As the drought seldom lasts more than 45 days a year, our present profit would be swallowed up with the interest charges. A system with reservoirs could handle the peak much better, though we doubt if water works peak loads, which are of very short duration, can be compared with the lighting load or street railway load which comes every day in the year.

Yours very truly,
DIVISION OF WATER,
H. C. Wight, Supt.

Dayton, Ohio,
Aug. 18, 1916.

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To the Editors: Referring to your editorial remarks on city water supply for irrigation: I regret to say that I cannot speak with confidence concerning the proposition on account of lack of personal knowledge and the fact that I have never studied agricultural methods.

Some years ago a gentleman presented an irrigation proposition for Southern New Jersey about which he was very enthusiastic. He proposed to raise early truck and have the time of ripening of his garden products under absolute control by irrigation. After giving this matter more or less study, I came to the conclusion that the rainfall in that section was too capricious, and that very often he might actually do harm with his irrigation, while the cost to produce it would be more than the gain in products.

In order to test this out, a small tract of say one-quarter to one acre should be experimented with for two or three seasons. I presume that has been done in a number of cases and the results constitute the basis of your conclusion.

Most of the water supplies with which I have been identified are considered very precious, and average prices much below 15 ct. per thousand gallons would be prohibitory. For irrigation purposes such prices would probably not be warranted. Then, again, when the water is needed for irrigation, it is needed very badly and in copious quantities. Unless a water company goes to the expense of providing large storage and large pipes, it cannot supply such peak demands with financial advantage.

There are three or four extremely objectionable features connected with water-works distribution systems: One is a hydraulic elevator; another is a railroad water crane (or standpipe); another is a hopper water-closet, and the worst of all is a lawn sprinkler, and intelligent water works managers do all they can to penalize the use of these devices.

A lawn sprinkler flows at the rate of from 5,000 to 20,000 gal. per day when running, or say an average of 10,000 gals., so it would take only 100 of them to discharge at the rate of 1,000,000 gals. in 24 hours. This is a serious drain on the water system, occuring at a time when the water company needs the water worst, and for such a small percentage of the year that the revenue would not be profitable. Yours truly,

SIMPLEX VALVE AND METER CO.,
B. J. W. Ledoux.

Philadelphia, Pa.,
Aug. 3, 1916.

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## EVANSTON INTERCEPTING SEWER, CHICAGO, ILL.

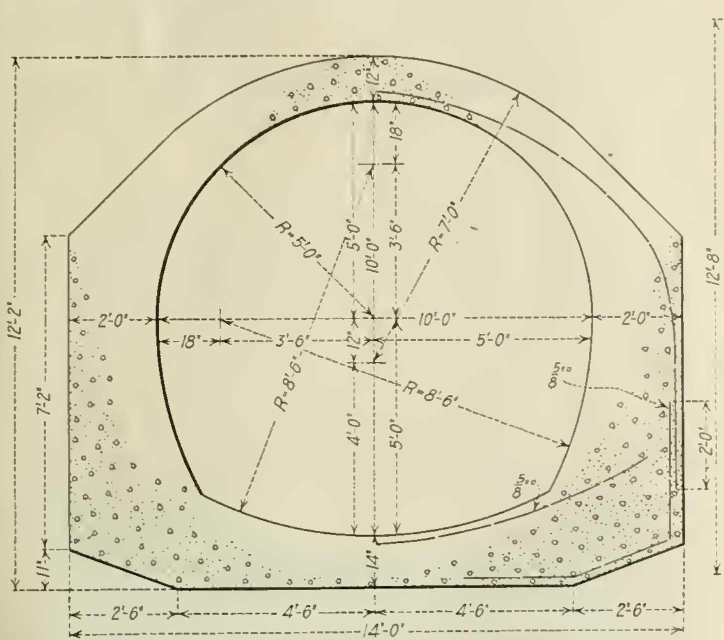


Fig. 1—Concrete Section.

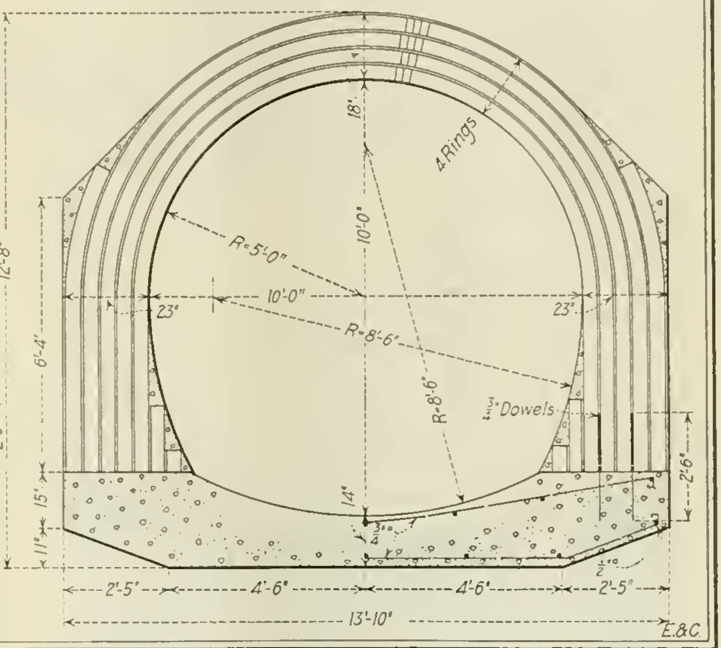


Fig. 2—Brick and Concrete Section.

Bids were opened Aug. 31 by the Trustees of the Sanitary District of Chicago for Contract No. 1 for the construction of the Evanston intercepting sewer. This sewer is to connect existing sewers along the shore of Lake Michigan in the city of Chicago and the city of Evanston, with the North Shore Channel of the Sanitary District. The contract includes the building of the following amount of sewers, 24-in. or larger in size:

| Diameter, ft. | Length, ft | Diameter, ft. | Length, ft. |
|---|---|---|---|
| 10 | 5,106* | 5 | 3,758* |
| 10 | 1,895† | 4½ | 8,019* |
| 7½ | 964* | 4 | 1,381* |
| 7 | 1,990* | 3½ | 5,174* |
| 6 | 4,977* | 3 | 1,302 |
| 6 | 1,106† | 2 | 2,697* |

*In open cut. †In tunnel.

In addition there will be several thousand feet of 26-in. and smaller tile pipe sewer, manholes, outfalls, crossings under railroads, etc.

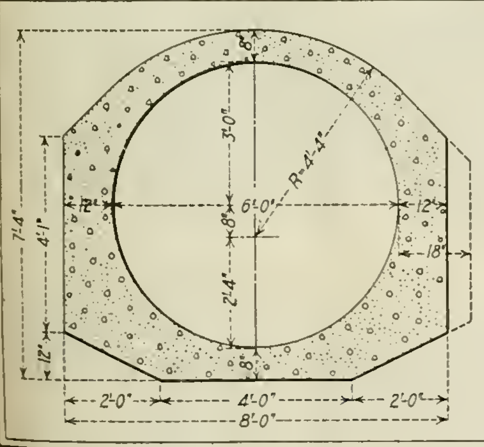


Fig. 3—Brick Section.

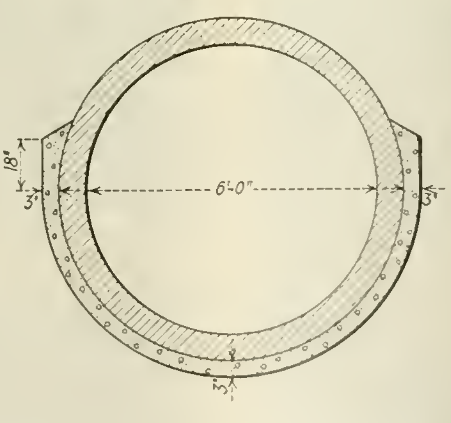


Fig. 4—Reinforced Concrete Pipe and Segment Block Section.

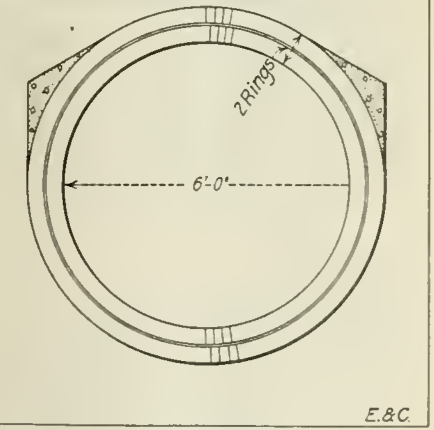


Fig. 5—Brick Section.

The 10-ft. sewer will be horseshoe shaped, and the remaining sizes will be circular. Alternate bids were asked on different types of construction. For the 10-ft. sewer bids were taken on concrete and on brick and concrete. The sections of this size as proposed for construction in Lake St. (5,106 ft. in length) are shown in Figs. 1 and 2. For the other sizes bids were received on brick, concrete, segmental blocks, and reinforced concrete pipe. Sections for the 6-ft. sewer for Elmwood Ave., 3,677 ft. in length, are shown in Figs. 3, 4 and 5.

The concrete sewer shown in Fig. 1 will require 2.54 cu. yds. of concrete per lineal foot. The reinforcement is to be placed as ordered by the engineer. In general on hard bottom no reinforcement will be necessary, but on soft bottom the invert is to be reinforced. This section will require about 11½ cu. yd. of excavation per lineal foot and 5.41 cu. yd. of surplus excavation. The average cut for the work in Lake St. will be 19 ft. for 4,200 ft. of the sewer and 25 ft. for 906 ft. The concrete will be a 1:2½:4½ mix. These proportions also will be used for the concrete in the invert of the combination brick and concrete sewer shown in Fig. 2. The specifications for the reinforced concrete pipe sewers call for the use of a 1:2:4 mix. The pipe is to be of the bell and spigot type, made in sections not less than 3 ft. in length. The shell thickness is to be as follows:

| Diameter ft. | Thickness, ins. | Diameter, ft. | Thickness, ins. |
|---|---|---|---|
| 3 | 4 | 4½ | 5½ |
| 3½ | 4½ | 5 | 6 |
| 4 | 5 | 6 | 7 |

The reinforcing steel must be not less than ¾ in. from the inner to outer surface of the pipe at all points. A wire fabric, bar or rod reinforcement could be used. It was provided that the circular reinforcement should consist of either one layer placed elliptically in the shell of the pipe with the major axis horizontal when the pipe is laid, or of two layers concentric with and placed near the inner and outer surfaces of the pipe. The cross section of elliptical reinforcement was to be not less than 0.4 of 1 per cent of the shell area in the longitudinal section. The pipe was to be bedded in 1:3:6 concrete. The specifications called for the use of the interlocking joint type of segmental tile. The blocks, preferably, were to make up two courses of tile, the inner and outer rings interlocking and breaking all joints. A single ring type with approved interlocking joint also will be permitted. A cradle of 1:3:6 concrete will be used.

The total of the bids received on Contract No. 1, all bidders being from Chicago, were as follows:

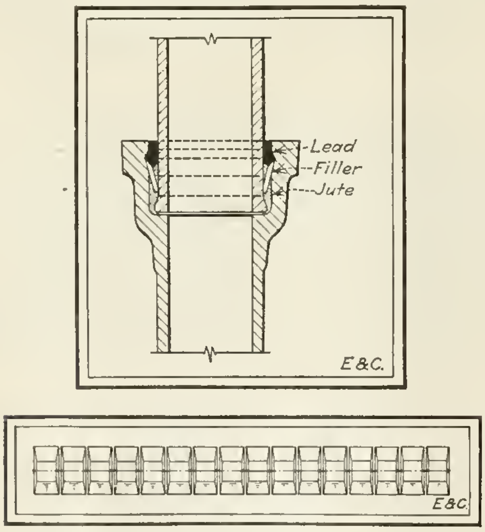
| | Concrete. | Brick. | Segmental Block. | Reinforced Concrete. Pipe. |
|---|---|---|---|---|
| Nash-Dowdle Co. | $841,631 | $904,347 | ........ | ........ |
| Nash Bros. | 868,518 | 932,445 | ........ | ........ |
| Byrne Bros., Dredging & Engineering Co. | 1,194,770 | 1,354,413 | 1,365,445 | 1,382,143 |

The unit bidding prices (per lineal foot) on the 5,106 lin. ft. or 10-ft. sewer in Lake St. and on the 3,677 lin. ft. of 6-ft. sewer in Elmwood Ave. were as follows:

| | Nash-Dowdle. | Nash Bros. | Byrne Bros. |
|---|---|---|---|
| 10 ft. concrete sewer | $35.00 | $35.25 | $49.50 |
| 10 ft. brick and concrete sewer | 39.00 | 39.75 | 60.00 |
| 6 ft. concrete sewer | 17.00 | 17.50 | 26.00 |
| 6 ft. brick sewer | 19.00 | 19.25 | 29.50 |
| 6 ft. segmental block sewer | ..... | ..... | 30.00 |
| 6 ft. reinforced concrete pipe sewer | ..... | ..... | 31.00 |

## A TIGHTENING WEDGE FILLER FOR CAST IRON PIPE JOINTS.

Custom, and in a measure perhaps prejudice, has established a standard form of bell and spigot joint for cast iron pipe, departure from which is not easily effected. This joint requires such an amount of lead for calking that any successful means for reducing its volume is of concern to the water works manager. In the accompanying illustrations is shown a device for reducing the lead required for pipe joints, and incidentally for increasing the strength of such joints. The section shows a standard joint made with the new filler. The filling is started with jute in the usual manner. The wedge ring is then bent around the spigot and pressed into the joint. A second calking with a small amount of jute follows to force the wedge ring out from the spigot and tight against the inside of the bell. The final step is pouring the lead in the usual manner. The feature of this joint is the ring of wedges, a section of which is shown by the sketch. These wedges are of cast iron, cast like beads into a steel wire. The wedges are cast in strings of different lengths to fit joints of different diameters. The advantages of the construction described are a saving of nearly 50 per cent in the amount of lead required for calking, a joint which tightens under internal pressure or when the pipe deflects, a more rigid joint without damaging loss of flexibility, a saving of labor in calking. The wedge filler is made by the American Cast Iron Pipe Co., of Birmingham, Ala.



Tightening Wedge Filler for Cast Iron Pipe Joints.

## FOUNDRY REJECTIONS OF CAST IRON PIPE, HARTFORD, CONN., WATER WORKS.*

During the past four years the Hartford Water Department has purchased 16,750 tons of cast iron water pipe. Of this 10,886 tons were of 42-in. pipe and 5,864 tons of pipe varying in size from 4 in. to 24 in.

Inspection is paid for at a rate per ton of pipe actually inspected, whether or not accepted on the order. On the smaller-sized pipes for the distribution system, the maximum rejection is 61.9 per cent, and the minimum 3.2 per cent. In the total there was an average of about 11 per cent of rejections; or, in other words, for every ton of pipe accepted, 1.124 tons were inspected. If the inspection charge was 25 ct. per ton, this would mean an actual cost of about 28 ct. per ton for the net quantity purchased. The causes of these rejections are, of course, oftentimes unavoidable, but probably careless foundry methods are responsible for a large part of this trouble. Since this matter has been in my mind, I have been watching the reports from the various foundries from which we have purchased pipe and I find that there is considerable difference in the amount and character of the rejections. This being the case, the conclusion seems obvious that, as stated above, carelessness, lack of skilled help, and improper iron mixture are responsible, in part at least, for a large number of rejections. If this is so, a method of correction, perhaps, would be to set a limit to the total amount of rejections that would be allowed and deduct from the pipe bill the amounts of the inspector's charge in excess of this amount. As a question for discussion, I would suggest 10 per cent as the maximum amount of rejections to be paid for by the purchaser, amounts in excess of this to be borne by the foundry. An alternative of this suggestion might be to allow the foundry to submit only such pipe as they choose for inspection, and then to charge against the foundry all cost of inspection in excess of, say, 5 per cent. The reason for setting 10 per cent as the limit was reached after study of the percentages from the several foundries. It was found that about 3,000 tons, or 45 per cent of the total inspection, varying in sizes from 4 to 20 in. in diameter, was furnished by one company. Of this amount of pipe, 75 per cent was passed with 7.5 per cent or less rejections, and 33 per cent with less than 5 per cent rejections. Some such action as this, I feel sure, would have a tendency to result in fewer rejections and a better class of pipe in the foundries where the present percentage of rejection is quite large. Such conditions, as noted above, indicate also the necessity of careful inspection at the foundry, whether the pipe be cast on order or taken from the stock pile. This reference to foundry shortcomings in no way reflects on cast-iron pipe itself, which I believe to be the best material which has been proposed thus far for distributing water. Neither do these criticisms apply equally to all foundries and makers of cast-iron pipes. Every foundry can turn out first-class products if so desired. Several of them are ordinarily supplying such a high grade of goods that competent purchasers prefer to place orders with them without competition when specially important work is to be undertaken.

The following tabulation applies to 42-in. pipes purchased for the Nepaug pipe line. Inspection shows that the rejections on this purchase were very reasonable in amount, that percentage of cut pipe was not excessive, and the variation in weight was within the limits stated in standard specifications.

| | Straight Pipe. Tons. | Specials. Tons. |
|---|---|---|
| Total weight inspected | 12,049.27 | 109.9955 |
| Total weight paid for | 10,885.88 | 98 1945 |
| Weight rejected | 1,163.39 | 11.8010 |
| Rejection of total cast | 9.6% | 10.7% |
| Total number of pipes accepted | | 3,294 |
| Total number of pipes rejected | | 352 |
| Per cent rejected | | 9.6 |

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*Excerpt from a paper by C. M. Saville in Journal, New England Waterworks Association, June, 1916.

## DETERMINATION OF ROUGHNESS COEFFICIENT FOR KUTTER'S FORMULA FOR DREDGED DITCHES IN BOLIVAR COUNTY, MISSISSIPPI.*

These investigations or experiments were made with a view to determining the value of the roughness coefficient, n, in Kutter's formula.

**Methods Employed.**—Chezy's formula is generally used for the determination of the mean velocity of flow in an open channel; it is,

$$v = c\sqrt{rs}$$

where $v$ = the mean velocity of flow in feet per second
$r$ = the hydraulic radius in feet
$s$ = the slope of water surface = ratio of fall to length
$c$ = a coefficient determined by experiment or computed by Kutter's formula, which is,

$$c = \frac{\dfrac{1.811}{n} + 41.65 + \dfrac{0.00281}{s}}{1 + \dfrac{n}{\sqrt{r}}\left(41.65 + \dfrac{0.00281}{s}\right)}$$

where $n$ = an empirical coefficient, its value depending upon the roughness of the wetted perimeter.

In the experimental determination of the value of n in Kutter's formula, the coefficient c is first obtained from Chezy's formula, and then the value of n by solving Kutter's formula. To do this it is necessary to determine r, s, and v by actual field measurements.

For the determination of these field data, a straight and practically uniform course of channel was selected on each of the canals, in such a location that no surface water entered the channel along this course. The gaging station for measuring the discharge was located somewhere along the course.

The slope of the water surface was determined by making vertical measurements from permanently set reference points to the surface of the water. These reference points were placed on arms extending horizontally from vertical posts set firmly in the ground at each end of the course. Variations in water level of from 3 to 4 ft. could be measured from each post and a sufficient number of posts were set along the slope of the bank so that all fluctuation in water surface could be measured. The elevations of the points on the arms of the posts were determined accurately with a level and were checked to within about .001 ft. Vertical measurements from the points on the arm to the water surface were made with a simple hook-gage rod.

Cross sections were made of each canal with an engineer's level. These sections were plotted and the areas and wetted perimeters were obtained for different stages by aid of a planimeter and a map measurer. The hydraulic radius was determined from these data for each

**Views of Dredged Canal Gaged in Determining N in Kutter's Formula.**
I. Gaging station and course of slope measurements, Pecan Bayou.
II. Showing condition of Pecan Bayou just below slope course.
III. Course of slope measurements, East Bogue Hasty.
IV. Gaging station and course of slope measurements, West Bogue Hasty.

**Views of Dredged Canal Gaged in Determining N in Kutter's Formula.**
V. Sand bar at mouth of lateral ditch, West Bogue Hasty.
VI. Gaging station and course of slope measurements, Bogue Hasty.
VII. Course of slope measurements, Bogue Phalia.
VIII. Gaging station, Bogue Phalia.

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*Extract from report by Charles E. Ramser, Drainage Engineer, Office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

TABLE I.—HYDRAULIC ELEMENTS AND VALUES OF n IN KUTTER'S FORMULA, BOGUÉ PHALIA.

Average dimensions of channel: Top width, 92 ft.; bottom width, 44 ft.; depth, 18 ft.

| No. | Gage Height. | Date of Observation. | Average maximum depth. Ft. | Surface width. Ft. | Slope. | Mean Hydraulic Radius. Ft. | Mean velocity. Ft. per sec. | Average cross-section. Sq. ft | c. | n. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.. | 118.30 | 1-14-15 | 4.20 | 57.5 | .000297 | 3.11 | 2.44 | 192.0 | 80.2 | .0223 |
| 2.. | 120.32 | 2-13-15 | 6.20 | 63.3 | .000159 | 4.61 | 2.12 | 320.0 | 78.3 | .0247 |
| 3.. | 122.16 | 2-11-15 | 8.05 | 68.5 | .000132 | 5.79 | 2.06 | 440.0 | 74.5 | .0276 |
| 4.. | 123.55 | 2-10-15 | 9.45 | 72.5 | .000118 | 6.65 | 2.06 | 535.0 | 73.6 | .0288 |
| 5.. | 124.96 | 2-9-15 | 10.85 | 76.5 | .000104 | 7.49 | 2.13 | 640.0 | 76.3 | .0286 |
| 6.. | 125.20 | 1-27-15 | 11.10 | 77.3 | .000127 | 7.67 | 2.49 | 657.0 | 79.9 | .0272 |
| 7.. | 126.28 | 2-8-15 | 12.20 | 79.8 | .000102 | 8.38 | 2.20 | 350.0 | 75.3 | .0300 |
| 8.. | 128.90 | 2-2-15 | 14.80 | 86.1 | .000195 | 10.00 | 3.24 | 970.0 | 73.3 | .0313 |
| 9.. | 128.90 | 2-4-15 | 14.80 | 86.1 | .000165 | 10.00 | 3.02 | 970.0 | 74.3 | .0311 |

Note—Banks fairly regular but caving badly; banks very regular for low stages; very little growth in channel.

TABLE II.—HYDRAULIC ELEMENTS AND VALUES OF n IN KUTTER'S FORMULA, BOGUE HASTY.

Average dimensions of channel: Top width, 56 ft.; bottom width, 35 ft.; depth, 8.6 ft.

| No. | Gage Height. | Date of Observation. | Average maximum depth. Ft. | Surface width. Ft. | Slope. | Mean Hydraulic Radius. Ft. | Mean velocity. Ft. per sec. | Average cross-section. Sq. ft. | c. | n. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.. | 135.00 | 1-5-15 | 2.55 | 38.1 | .000152 | 1.85 | 0.67 | 74.8 | 39.9 | .0382 |
| 2.. | 136.50 | 1-20-15 | 4.05 | 42.3 | .000183 | 3.01 | 1.34 | 137.0 | 57.1 | .0309 |
| 3.. | 138.05 | 2-25-15 | 5.60 | 47.2 | .000119 | 4.08 | 1.32 | 209.0 | 59.8 | .0318 |
| 4.. | 138.20 | 2-22-15 | 5.75 | 47.3 | .000166 | 4.10 | 1.74 | 210.8 | 66.7 | .0285 |
| 5.. | 140.25 | 2-23-15 | 7.80 | 53.3 | .000169 | 5.30 | 2.07 | 314.0 | 69.2 | .0290 |
| 6.. | 141.95 | 1-25-15 | 9.50 | 58.2 | .000157 | 6.31 | 1.90 | 414.0 | 60.4 | .0350 |
| 7.. | 142.73 | 12-26-14 | 10.30 | 58.5 | .000217 | 6.73 | 2.08 | 450.0 | 54.3 | .0396 |
| 8.. | 143.52 | 2-1-15 | 11.05 | 59.2 | .000168 | 7.38 | 2.22 | 503.0 | 63.1 | .0347 |
| 9.. | 144.10 | 2-3-15 | 11.65 | 59.6 | .000135 | 7.64 | 1.95 | 537.0 | 60.8 | .0366 |

Note—left bank regular and quite free from vegetation. Right bank irregular; upper part covered with weeds and caving badly.

section and the mean of all the hydraulic radii was taken as the mean hydraulic radius for the course.

The mean velocity, v, was obtained by taking the mean of the velocities as found at each section, and the mean velocity at each section was determined by dividing the discharge of the stream, in cubic feet per second, by the area of the section. The discharge from which the mean velocity was obtained was computed from measurements made of the cross-sectional area and of the velocity at the gaging section. The method employed for determining the velocity and the discharge was similar to that described in the foregoing report on Run-off Investigations.

Discharge and slope measurements of the streams were made for several different stages of each stream and duplicate measurements were made of the same when the conditions governing the slope varied.

Experiments for the determination of the value of n were made on the following streams: Bogue Phalia, Bogue Hasty, West Bogue Hasty, East Bogue Hasty and Pecan Bayou. The conditions and results on each of these streams will be discussed separately.

### Bogue Phalia.

**Location and Description of Course.**—The conditions for accurate discharge and slope measurements on this canal were ideal. A straight course of practically uniform cross section was selected for slope measurements, about a half mile above the Y. & M. V. R. R. bridge, 2 miles from Helm. The length of the course was 1,003 ft. The gaging station was located near the lower end of the course and the velocity measurements were made from a movable car suspended from a steel cable which was stretched across the stream at right angles to the direction of flow and supported by upright poles on either bank. (See Plates VII and VIII.)

**Condition of Channel.**—The left bank of Bogue Phalia along the course is quite regular, while the right bank is caving badly and is only fairly regular. The channel for low stages is very smooth and of uniform section. Very little vegetation of any sort was found in the channel. The soil in the lower part of the channel is sandy. That in the upper part is a clay loam of close texture and is quite susceptible to caving, particularly when wet.

**Slope Measurements.**—Nine sets of simultaneous slope and discharge measurements were made at stages varying from low to high. The slope was indeed an extremely variable quantity. No two measurements of slope were found to be the same, due to the backwater conditions. The greatest slope was found for the lowest stage and the others varied accordingly to the effect of backwater at the time that measurements were made.

**Results.**—The principal hydraulic elements of the canal and the values of c and n obtained therefrom are shown in Table I. Very little variation was found in the values of c, and the values of n were found to vary from .0222 for the lowest stage to .0313 for the highest. As would be expected, the values of n are found to be low for the lower stages where the channel is quite smooth and uniform in section, and higher for the higher stages where a greater resistance is offered to flow by the rougher and more irregular sides of the channel. On the whole, this channel can be said to be in excellent shape, a fact which is substantiated by the comparatively low values of n obtained.

### Bogue Hasty.

**Location and Description of Course.**—The course used for slope measurements on Bogue Hasty was 1,039 ft. long. It is straight and fairly uniform and no water through drain tile or surface ditches enters the channel along the course. It is located just above the highway bridge about 3 miles west of Shaw. The lower end of the course is above a slight bend in the channel and about 500 ft. above the bridge. The gaging station, which consisted of a suspension foot bridge (75-ft. span), was placed near the lower end of the course. The conditions for both slope and discharge measurements were very good. (See Plate VI.)

**Condition of Channel.**—This channel was not found to be in as good condition as that of Bogue Phalia. The right bank was very irregular and was caving badly. The upper part was covered with weeds and small tree sprouts. The left bank was very regular and practically free from vegetation. The soil in the upper part of the channel is a dark silty loam and in the lower part a light yellow clay. It is sticky when wet and cracks and crumbles when dry.

**Slope Measurements.**—Nine measurements for slope and discharge were made for different stages of the stream. The variations of slope shown in Table II were due to the effect of backwater.

**Results.**—Table II shows the hydraulic elements and the values of c and n obtained from these experiments. The value of n (.0382) for extreme low stage is the highest value but one obtained and is probably due to the irregularities in the bed of the channel. The values of n obtained for measurements 2 to 5 inclusive are applicable to the lower half of the channel and they agree quite closely with those obtained for Bogue Phalia at bank full stage, the conditions of smoothness and regularity of the channel being very similar. The values of n obtained for the upper half of the channel are considerably higher than for the lower part. The very irregular and caving right bank would lead one to expect a larger roughness coefficient for bank full stage than for the lower half.

### West Bogue Hasty.

**Location and Description of Course.**—For slope measurements on this canal a straight course 757 ft. long of quite uniform cross section was selected north of the highway bridge about 1 mile east of Litton. Very little water enters the channel along this course. Stakes for slope measurements for the upper end of the course were located about 50 ft. above the entrance of a lateral surface ditch. The gagings for discharge were made from a suspension foot bridge built about in the middle of the course. (See Plate IV.)

**Condition of Channel.**—The collection of drift by the bridge below the course, and sedimentary deposits as a result of the drift and the entrance of a lateral ditch just above the bridge (see Plate V), rendered this course unsuitable for accurate determinations of the value of n. During periods of no flow a pond of stagnant water stands nearly the whole length of the course, this being due to the sediment deposited near the bridge. The banks and bed of the channel are quite regular. Some weeds were found on the banks of the channel. The soil is similar to that found in the channel of Bogue Hasty.

**Results.**—Only four measurements of the slope were made. The values of n obtained for these measurements are shown in Table III. All values are high; this is attributed to the effect of the sedimentary deposit below which impounded considerable water during low stage.

### East Bogue Hasty.

**Location and Description of Course.**—The course for slope measurements on East Bogue Hasty was established about 2 miles east of Litton, above the highway bridge. A stretch of 502 ft. was selected, its upper end being just below a curve in the channel and the lower end just above the bridge and the entrance of a lateral ditch. The discharge measurements were made from a suspension foot bridge about midway of the course. This course was rather short for accurate determinations of slope, but it was the straightest stretch of uniform section that could be found near the lower end of the canal. (See Plate III.)

**Condition of Channel.**—The banks and in some places the bed of the channel were covered with weeds and weed stubble and the banks were slightly irregular. Practically no caving took place along the course, which fact was due no doubt to the vegetation covering the banks. The soil is a dark-colored clay which cracks and crumbles when dry.

**Results.**—The values obtained for n are shown in Table III, and as would be expected from the condition of the channel are even higher than those found for bank-full stage of Bogue Hasty. Some trouble was experienced during the measurements due to drift collected at the bridge and this may be in part responsible for the rather high values obtained for n.

### Pecan Bayou.

**Location and Description of Course.**—A course 665 ft. long was used for slope measurements on Pecan Bayou, located about 600 ft. above the highway bridge, 5 miles directly south from Skene. The section of the channel at this place is extremely uniform and no surface water enters along the course. It is situated between two bends in the channel. A suspension foot bridge was placed near the lower end of the course for gaging purposes. (See Plate I.)

**Condition of Channel.**—Conditions on Pecan Bayou are similar to those described for West Bogue Hasty. Much water is impounded along the course for periods of no flow. It appears that material was deposited in the channel below to impound water for the purpose of fishing. (See Plate II.) The banks of the channel are very regular. Some weeds were found in the channel, but not nearly as many as in the channel of East Bogue Hasty. The soil is quite similar to that in the channel of East Bogue Hasty.

TABLE III.—HYDRAULIC ELEMENTS AND VALUES OF N IN KUTTER'S FORMULA—PECAN BAYOU.

Average dimensions of channel: Top width, 24 ft.; bottom width, 11 ft.; depth, 6 ft.

| No. | Gage Height. | Date of Observation. | Average maximum depth. Ft. | Surface width. Ft. | Slope. | Mean Hydraulic Radius. Ft. | Mean velocity. Ft. per sec. | Average cross-section. Sq. ft. | c. | n. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.. | 140.50 | 2-25-15 | 4.35 | 20.8 | .0000256 | 2.79 | 0.54 | 67.5 | 63.9 | .0267 |
| 2.. | 140.60 | 2-22-15 | 4.45 | 21.0 | .0000676 | 2.85 | 0.76 | 70.0 | 54.7 | .0315 |
| 3.. | 142.62 | 2-24-15 | 5.85 | 23.5 | .0000271 | 3.63 | 0.51 | 102.6 | 51.3 | .0366 |
| 4.. | 142.50 | 2-24-15 | 6.35 | 24.3 | .0000271 | 3.82 | 0.60 | 113.5 | 59.0 | .0320 |
| 5.. | 143.10 | 2-23-15 | 6.95 | 25.5 | .0000782 | 4.04 | 0.87 | 127.5 | 49.0 | .0395 |
| WEST BOGUE HASTY.<br>Average dimensions of channel: Top width, 34 ft.; bottom width, 21 ft.; depth, 7 ft. | | | | | | | | | | |
| 1.. | 139.21 | 2-31-15 | 2.55 | 26.5 | .0001110 | 2.22 | 0.55 | 59.0 | 35.0 | .0455 |
| 2.. | 140.52 | 2-25-15 | 4.17 | 29.2 | .0000806 | 2.97 | 0.68 | 97.5 | 44.0 | .0397 |
| 3.. | 112.10 | 12-31-14 | 5.75 | 32.3 | .0000515 | 3.79 | 0.57 | 143.0 | 40.8 | .0468 |
| 4.. | 142.15 | 2-24-15 | 5.80 | 32.5 | .0000753 | 3.82 | 0.74 | 145.0 | 43.6 | .0436 |
| EAST BOGUE HASTY.<br>Average dimensions of channel: Top width, 24 ft.; bottom width, 12 ft.; depth, 6.5 ft. | | | | | | | | | | |
| 1.. | 139.11 | 3-31-15 | 2.51 | 16.6 | .000231 | .... | 0.66 | 30.5 | 33.4 | .0438 |
| 2.. | 141.20 | 2-25-15 | 4.61 | 22.2 | .000211 | .... | 1.11 | 72.5 | 45.7 | .0377 |
| 3.. | 142.70 | 2-14-15 | 6.11 | 25.8 | .000173 | .... | 1.28 | 107.5 | 52.5 | .0347 |
| 4.. | 143.00 | 12-31-14 | 6.41 | 26.4 | .000249 | .... | 1.30 | 115.0 | 43.5 | .0424 |

**Results.**—The slope of the water surface was found to be exceedingly low; much less than the grades designated in the construction of the canal. This is due no doubt to the amount of sediment deposited in the channel below and along the course. The values of n obtained are shown in Table III.

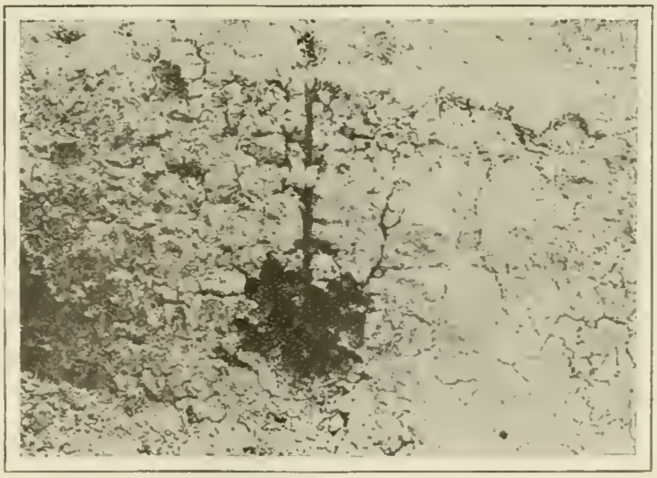
### Conclusions.

From the foregoing description of the results obtained and the conditions existing on each of the canals, it is apparent that the most dependable data were obtained from the Bogue Phalia and Bogue Hasty canals. These results show that values of n between .025 and .030 obtain where the governing conditions and general characteristics are similar to those described for the lower half of the channel of Bogue Phalia, and a value of n of about .030 or slightly larger for channels similar to the whole channel of Bogue Phalia and the lower part of Bogue Hasty. However, since few drainage channels are maintained in the condition that exists for the lower part of Bogue Phalia, it does not seem advisable to recommend a value for n less than .030 in the design of drainage channels similar to the ones herein described.

The other values obtained for the whole channel of Bogue Hasty, Pecan Bayou, and East and West Bogue Hasty, demonstrate the effect of the conditions described upon the value of n. These values can be used as a guide in the design of drainage channels where like conditions can reasonably be expected to exist due to the lack of maintenance of the channels or to the caving in of the banks. These data ought also to serve a useful purpose in estimating the discharge of old channels where like conditions prevail.

## GOPHER DITCH CONSTRUCTION.

The illustration shows a gopher ditch construction on the lands of the Santa Ana Sugar Co. in Southern California. This is a type of ditch of which many miles have been constructed for sub-surface drainage. It has the advantage over open ditches that no land is taken from cultivation and no barrier is formed to free travel for agricultural operations. It calls for less investment than tile drains. Its disadvantage is the possibility of complete closure by caving. A short life would also seem to be natural, but it is stated that it has been found that gopher ditches will give service from 5 to 14 years, depending upon the character of the ground.



Gopher Ditch for Land Drainage.

The construction of gopher ditches requires special machinery. At the Santa Ana farms the outfit comprised a special gopher ditch plow and three Holt caterpillar tractors for hauling the plow. The plow is the special tool. It consists of a strong carriage, which rides on the surface and carries, projecting downward, the plow proper, which can be raised and lowered by suitable mechanism. Attached to its heavy framework is a single knife-blade beam, thin enough to avoid any great disturbance on the surface of the soil, yet wide enough to give it strength for withstanding the terrific strains to which it is subjected. The construction of this part of the tool is very similar to that of a subsoiler. At the point, however, there is attached a torpedo-shaped affair, made of steel; this is the gopher.

In operation, the gopher is run down 4 ft. below the surface of the ground and is then pulled straight forward. The plow used by the Santa Ana Co. had a gopher 8 in. across, so that it made a drain ditch 8 in. in diameter. The point of the gopher is so shaped that, as it is forced through the ground, it spreads the dirt evenly to all sides of it, packing it tight and making a solid, smooth-faced closed ditch.

## SUGGESTED MILK OF LIME CURE FOR RED WATER, MONTCLAIR, N. J., WATER SUPPLY.*

The water supply of the city of Montclair is obtained from the Montclair Water Co., which has its source at the Passaic River at Little Falls. At this point the water of the Passaic River is filtered through a modern mechanical filter plant using sulfate of alumina as a coagulant. The water is then sterilized by the application of liquid chlorine, and pumped to the distribution system. A balancing reservoir is maintained at Great Notch, but very little of the water used at Montclair actually passes through this reservoir. The character of the Montclair water, as derived from the river, is what may be termed soft, with an appreciable amount of free carbonic acid present. As delivered to the city of Montclair, after filtration, it is low in the carbonates of lime and magnesia, and higher in free carbonic acid.

Due to corrosion in the house pipes this water at the taps is discolored so as to be objectionable. It is recommended that the corrosion be checked by reducing the free carbonic acid by dosing the water at the filter wells with milk of lime. The report says:

If we assume that the average amount of free carbonic acid in the filtered water will be no higher than 12 parts per million, then the lime hydrate required to neutralize it will average 2,625 lbs. per day at the present rate of pumpage, which is 33,000,000 gal. per day.

The cost of 2,653 lb. of lime per day at one-half cent per pound will be $13.27. This will amount to approximately $5,000 per year for chemicals.

The apparatus by which lime solution, or "milk of lime," as it is usually termed, is applied, consists of solution tanks with mechanical agitators, and a device for applying the solution proportionately to the volume of water to be treated. Such an apparatus capable of treating the water even under conditions of maximum carbonate content, may be installed for about $2,000.

This estimated cost does not include a new building as the tanks and dosing apparatus may readily be installed in the present chemical house. In fact, it may be found possible to modify the equipment now used for the application of soda ash, so that it may be used for the application of the lime solution. The only additional cost of installation may then be safely figured at $2,000. The yearly interest and reserve for depreciation on this sum will be covered by 10 per cent or $200 per year.

The installation of such a plant should add very little to the cost of operation of the filter plant. There will be some costs, no doubt, but they would be easily covered by the sum of $500 per year.

The total annual cost, therefore, for installing and operating a plant for the application of lime hydrate should not exceed $6,000 per annum.

The total population served is about 400,000.

The quantity of water filtered annually is 11,889,000,000 gal.

The cost per capita will, therefore, be about 1.5 ct. per annum, or about 50 ct. per 1,000,000 gal.

This is obviously much cheaper than any local remedy that could be applied, and we are of the opinion that a fair trial of lime hydrate over a sufficient period to effect proper adjustments of the dosage, and to admit of its effects being fully developed will prove its expediency. The lime should be continuously and intelligently applied for a period of at least one year before pronouncing upon its efficacy or inefficacy.

## REMOVING LEAD CALKING WITH THE BLOW PIPE.

(Contributed.)

The removal of lead calking from the joints of cast iron water mains has always been a serious problem. When, for any reason, it was necessary to take out a section for repair, or to insert an elbow, tee, or fitting in the line, old methods were both expensive and unsatisfactory, because of their slowness and liability to injure the pipe.

With hammer and chisel, it takes a man a day to a day and a half to remove the lead, with the constant danger of damage to the pipe. The flame of the Oxweld welding blowpipe has solved this problem. The photograph shows an operator at work on 40-in. mains. The lead was melted out with the blowpipe in an hour and a half. A small tip is used for this purpose that gets right inside the crevice and the flame is confined to the lead only, without affecting the pipe in any way.

Because of the many economies it makes possible, Oxweld welding and cutting equipment is rapidly becoming a standard part of the tool plant of progressive water works, the removal of lead calking being only one of the innumerable uses in which it saves time and money. For machinery repairs, the welding blowpipe is well-nigh indispensable, as the records indicate that at a negligible cost it has frequently repaired extensive castings and forgings, which often would have taken weeks to replace. In the construction of pipe line, it has also demonstrated its usefulness in many conclusive tests, since it produces an ideal joint, as permanent as the pipe itself, at a saving of fully 25 per cent to 40 per cent over mechanical couplings. By its use it is likewise possible to produce tees and fittings of the most complicated nature in record time. The cost of a welding and cutting outfit is not high. The sources of supply for gases are accessible to almost every city and any intelligent workman may easily be taught the methods of operation.

Removing Lead Calking from 40-In. Cast Iron Water Main With Oxweld Welding Blowpipe.

## REMARKABLE EFFICIENCY TEST OF IMHOFF TANK.

Contributed by H. V. Hinckley, Consulting Civil Engineer, Oklahoma City, Okla.

The writer recently tested the efficiency of an 18-ft. circular Imhoff tank, 21 ft. 8 in. deep, which was completed a year ago at Chelsea, Okla. The percentage of sedimentation obtained by this tank is so high that some apology seems to be due for publishing the result—average 98.4 per cent.

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*From report by Nicholas S. Hill Jr., for Montclair, N. J.

The tank is of reinforced concrete and has a circular 3-ft. gas chimney and sludge slopes of 1½ vertical to 1 horizontal. As the foreign war made it impossible to secure the regular Imhoff tubes, tin funnels were made 6x24 in. (capacity 235 cu. in.) set into glass test tubes ½x6 in. The splices were made with thin bicycle repair rubber wound around the joints with twine. These tubes were hung on a shelf 5 ft. high and depths of deposit were read on a scale held alongside the test tubes, the round bottoms of which had been previously filled with plaster of paris. The following results were obtained in two hours:

| Tube. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Where taken ............ | M. H. | Inlet | Outfall | M. H. | Inlet | Outfall |
| Inches in tube............ | 3 5/16 | 4½ | 0 1/16 | 4 | 1½ | 0 1/16 |
| Wet sludge, cu. in......... | .650 | .883 | .012 | .785 | .883 | .012 |
| Wet sludge, per 1,000.... | 2.76 | 3.76 | 0.04 | 3.34 | 3.76 | 0.04 |
| Per cent removal ......... | 98.1 | 98.6 | .... | 98.4 | 98.6 | .... |
| Per cent in effluent ...... | 1.9 | 1.4 | .... | 1.6 | 1.4 | .... |

The following are some of the reasons which might be accountable for the remarkable efficiency of this tank:

(1) A circular Imhoff gives radial dispersion and therefore, in my opinion, better settling results than the rectangular Imhoff.

(2) Slopes steeper than 45 degrees are helpful in preserving the non-septicity of the tank, but would hardly be expected to increase the percentage of sedimentation.

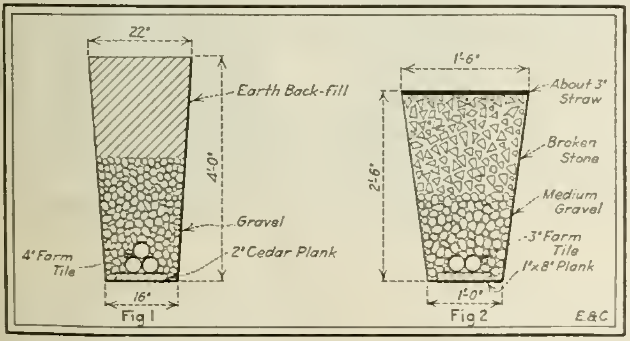
(3) This tank, which was built larger than would generally have been designed for 1,300 people, has two-hour settlement for 90,000 gal. in 18 hours while, with about 70 connections, the flow at 3 p. m. on date of test was 15,000 gal. per 24 hours. Differently stated, the present flow has an 18-hour settlement.

(4) The Sewer Committee reported that some trouble had been experienced in suppressing the newspaper nuisance, though at time of test the "censorship" was believed to be effective. There were evidences in the test tubes that the nuisance had not been fully abated and the excessive percentage of wet sludge in the table of results points to this nuisance as one of the causes contributing to the high efficiency percentages.

## COST OF LAYING TILE DRAIN ON TWO JOBS.

Contributed by H. R. Ferris, Victoria, B. C.

The following costs cover the work of laying 300 ft. of drains of the design and cross-section shown by the attached Fig. 1. All excavation in sandy loam surcharged with water (not quisksand). The ditch required close timbering in certain places. When finished the drain was of the attached cross-section, but the actual excavation was about 3½ ft. only, as a slight fill covered the top. The work was designed to be permanent, and has been in continual and satisfactory use for over three years. The costs follow:



Figs. 1 and 2—Sections of Tile Drains.

| | | Per lin ft. |
|---|---|---|
| Labor— | | |
| Foreman, 5 days @ $3.00.......................... | $ 15.00 | $0.050 |
| Labor, 174 hrs. @ $0.30.......................... | 52.20 | .174 |
| Materials— | | |
| Lumber (2x12 cedar), 600 ft. B. M. @ $18.00...... | 10.80 | .036 |
| Gravel, 25 cu. yd. @ $1.50....................... | 37.50 | .125 |
| Timber (bracing), 800 ft. B. M. @ $12.00......... | 9.60 | .032 |
| Tile (4-in. farm), 900 lin. ft. @ $0.03.......... | 27.00 | .090 |
| | $152.10 | $0.507 |

It was not practicable to separate the cost of laying planks, tile, etc. The labor (174 hr.) represents the total time on this work, with the exception of earth backfill, which was done several days later with team and scraper. The prices for materials include delivery along the work.

Figure 2. shows the drain construction for the second job, covering 1,900 ft. of drain. The costs were as follows:

| | | Cost per ft. |
|---|---|---|
| Labor — | | |
| Foreman, 98 hrs. @ 40c.............................. | $ 36.80 | $0.019 |
| Labor, 700 hrs. @ 30c............................... | 210.00 | .115 |
| Team, 12 hrs. @ 65c................................. | 7.80 | .001 |
| | $254.60 | |
| Materials— | | |
| Rough planks (1x8), 1,900 lin. ft. @ $8.00....... | $ 15.20 | .008 |
| Gravel, 160 cu. yd. @ $1.00......................... | 160.00 | .084 |
| Straw, 11 bales ...................................... | 6.60 | .003 |
| | $181.80 | |

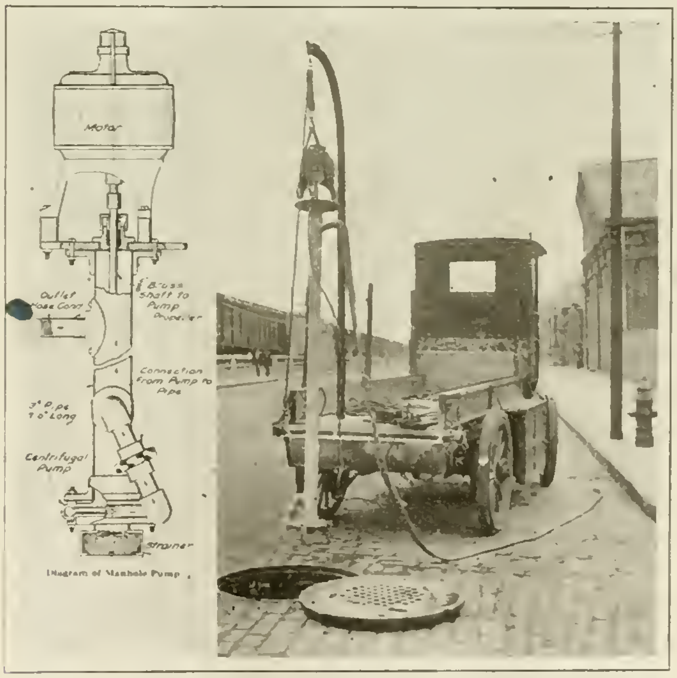
The prices for materials cover cost delivered along the line of the work. Cost of removing surplus earth is not included. Excavation was in stiff clay, and the work was performed in wet weather. Good foreman and average crew. The costs of excavation, backfilling with gravel, etc., were not separated.

Broken stone (30 cu. yd.) used in the drain was taken from a nearby sewer trench, which had been excavated in rock. This was delivered conveniently along the line of the trench, and the cost of delivery is not included in the above, but the cost, however, of the handling in the trench is included. In all about 190 cu. yd. of gravel and rock were used over the tiles.

## A MOTOR-DRIVEN MANHOLE PUMP.*

In the spring of the year and after heavy rains considerable trouble is experienced by the Underground Department of the Rochester Railway and Light Company because the manholes which have no drains are flooded with water above the cables.

The cable ducts connecting the manholes allow the water to flow from manhole to manhole until a number of manholes have become filled, making it necessary to pump the water out before any work can be done on the cables. In the past a hand pump was used. This was very tedious work, sometimes requiring one or two hours' continuous pumping. It was decided to design an electric driven pump and use material in the company's stock, if possible.



Manhole Pump Employed by the Rochester Railway & Light Co.

As shown in the accompanying illustrations, a ¼ hp. 1,400 r.p.m. vertical motor and a small centrifugal pump were connected by a 3-in. spiral riveted pipe 7 ft. long. The pipe acts as a support for the motor, is long enough so that the pump can be lowered into the water without submerging the motor and at the same time conducts the water from the pump to the street level. The shaft of the motor and the impeller of the pump are connected by a 5/8-in. brass rod running through the 3-in. pipe.

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*From data furnished by the Rochester Railway and Light Co., Rochester, N. Y. L. D. Hall, Chief Draftsman and L. C. Kimpal draftsman of the pump.

The complete apparatus weighs about 170 lb. and is supported by a small crane attached to one of the company's trucks. The crane is a small pipe with a long radius bend and hook at one end, so that the pump can be swung over the edge of the truck and lowered into the manhole by means of a block and tackle.

The pump requires only a small amount of power, and the motor is operated by the battery which operates the truck.

The utility of the pump is shown by the fact that it will empty a manhole in 15 minutes, whereas it would take two men almost an hour to do the same work with a hand pump. The pump is in operation every day, especially during the rainy season, and is in charge of Mr. O. Roth.

## A NEW ENGLAND PIPE LINE OF UNUSUAL LENGTH OF MACHINE-MADE WOOD PIPE.*

The old system, formerly owned by the Suncock Water Works Co. that supplied water to Suncook Village in the town of Pembroke and Allenstown, was never satisfactory, either in the fire service rendered or the quantity or quality of the water furnished, and was acquired in 1914 by the town of Pembroke. In order to secure a satisfactory source it was found necessary to go to Pleasant Lake, 14 miles distant, in the town of Deerfield, N. H. Lake Pleasant is 316 ft. above the lower level of Suncook Village. The supply pipe line, 14 miles in length, that is now nearly completed, is laid with 16-in., 14-in., and 12-in. wood stave pipe, and the suburban distribution line in Pembroke St., four miles in extent, with 8-in. and 6-in. wood pipe. One-half this pipe was purchased from the Wyckoff Co. of Elmira, N. Y., and the other half from the Michigan Pipe Co. of Bay City, Mich. The saving in first cost under what it would have cost to construct these lines with Standard cast-iron pipe is slightly over $52,000. A section where the wood pipe saved considerable expense and difficulty was in the first two miles from the source. Here the pipe was laid through a swampy tract of land; a portion of it was an impassable morass except when the surface is frozen. This two miles was laid in December and January. The surface at that time was frozen to a sufficient depth to allow teams to pass over it and provide a footing for the pipe layers. At places the flow of ground water was so copious that it required the continual use of a 6-in. Cameron steam pump operating day and night to care for it. The trench required close sheet piling, thoroughly braced. This was laid with 16-in. pipe, and it would have been almost an impossibility to have laid and calked cast-iron pipe in this section. As the lake is elsewhere surrounded by high hills and ridges, this was the only practical place to take a pipe line out of it. This pipe line was laid to a true grade. The bottom of the trench, which averaged about 10 ft. in depth, when the grade did not carry it through the mud or quicksand, was filled with brush and small wood removed from the right of way. the pipe was laid on this and weighted with sand bags, as it could not safely be filled with water until connected with the intake. Considerable difficulty was experienced by the clogging of the pumps first installed with vegetable matter and roots, but after securing the Cameron pump we had no further trouble of this kind. This supply line has been well equipped with both air and vacuum valves.

For the Pembroke St. installation, wood pipe was chosen, mainly for the reason that the Manchester and Concord Electric Ry. passes over almost its entire length, and as no provision for a return current is made there, an iron pipe line would undoubtedly have formed this circuit, with the danger of electrolysis imminent.

Ablett & Bowes of Cohoes, N. Y., are the contractors for this work, and the difficult part of it, consisting of laying the 16-in. pipe through the bog, was done on the percentage plan, and a considerable saving was made in this way.

## HINTS ON COMPUTING COSTS OF CLEANING AND PAINTING WATER WORKS STANDPIPES.

Contributed by Joseph Dixon Crucible Co., Jersey City, N. J.

Eperience teaches the practical painter the approximate amount of time necessary to clean a standpipe and water tank work. This depends upon the condition of the work at the time of repainting, which means the extent of corrosion, the character of paint previously used, and in both cases how difficult or easy is the removal of the old scale. A fair working average on a plain surface, such as the outside of a standpipe is 1 ct. per square foot, according to conditions. Raise this figure a little for inside work because of the greater amount of corrosion or greater difficulty in removing it. This estimate does not include the purchase of paint. Neither does it include the cost of brushes and tools which can be considered to represent a cost of 5 per cent, figuring upon the cost of make-up.

The average cost of cleaning by means of chipping and painting (no paint included) is 3½ ct. per square foot. The cost of sand-blasting and painting, including transportation of sand-blasting apparatus, within a reasonable distance, is 5 ct. per square foot. This company, however, recommends that all surfaces should be thoroughly cleaned by hammers and scrapers, or by steel-wire brushes.

Now, about the paint item. One paint may cost 50 ct. a gallon; a superior paint, which lasts longer, may cost $1.50 per gallon. One paint will cover 200 sq. ft.; another 500 sq. ft. per gallon. One paint can be more readily applied than another, thus saving in labor. We estimate that the actual cost in averaging the paint is 1½ ct. per square foot. Dixon's Silica-Graphite Paint, being easy to apply, and covering the maximum of surface, and costing net, say, $1.20 a gallon to consumers in barrels, will come to about 17½ ct. per square.

There is a difference in the cost of cleaning and painting the lattice work of uprights, on which the tanks are constructed, depending upon the position of the lattice work. The average length of columns is 100 ft. They are square in shape and average from 10 to 12 in. on all sides. Each 100 ft. of this class of work requires 3 gal. of paint per coat, and the total cost of cleaning, application and paint per 100 ft. is $18.

The outside bottom part of the average water tank costs $7 per 100 sq. ft., which includes scaffolding, cleaning, application and cost of paint.

All of the above figures are based on actual average cost, and the 15 per cent or 20 per cent labor profit that the painter charges for himself, so if the owner employs his own labor he can deduct that profit, but his labor might not be as expert as an expert water tank painter.

## WELDING WELL CASING WITH OXY-ACETYLENE TORCH.*

This well, on which we began work in November, 1911, is located about 4 miles out of McDonald, Pa., and at the time this paper was written had reached a depth of 7,181 ft., being by far the deepest well ever drilled in this country and only exceded by one other well in the world. At the time of which I write we had in the well a string of 3½-in. I. D. or 4½-in. O. D. casing 6,320 ft. long with heavy collars.

In order to use a larger sized casing it was decided to pull out the screw pipe and run in a string of 5-in. with welded joints. The casing was furnished in 21 to 23-ft. lengths, the first 2,000 ft. being 5-in. O. D. or 4.29-in. I. D., 0.355 in. thick, weighing 17.611 lb. per foot. Owing to the fact that there was an enormous water pressure on the lower casing it was heavier than that used above the water, which was 5 in. O. D. or 4.24 in. I. D., 0.288 in. thick, weighing 14.493 lb. per foot, there being 4,320 ft. of this or a total length of 6,320 ft. in the string. On both weights the ends of the joints were chamfered 60 degrees.

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*From a paper by Arthur W. Dudley in Journal, New England Water Works Association for September, 1916.

*From a paper by F. L. Hadley before the National Gas Association.

In placing the casing in the well there were two joints welded together outside of the derrick, then after the welding was completed these were placed in the hole and lowered down until only about 5 ft. remained above the derrick floor. Then two additional lengths were welded together in the yard as before and then brought into the derrick, raised and suspended in the air with the lower chamfered end resting upon the upper chamfer of the section previously placed in the well, then the welder proceeded to weld these sections together vertically, after which they were lowered into the hole.

## AN IMPROVED CENTRIFUGAL PUMP.

(Contributed.)

The development of the steam turbine and the high efficiency multi-stage centrifugal pump have gone hand in hand, but up to the present it has not been entirely practicable to reconcile the speeds of the two machines so that each would work at its best efficiency.

It was necessary, heretofore, to reduce the speed of the turbine and sacrifice much of its efficiency or else speed up the pump with similar results. To overcome this difficulty the Cameron Steam Pump Works, 11 Broadway, New York, have designed and built a multi-stage centrifugal pump, known as the "BT" type.

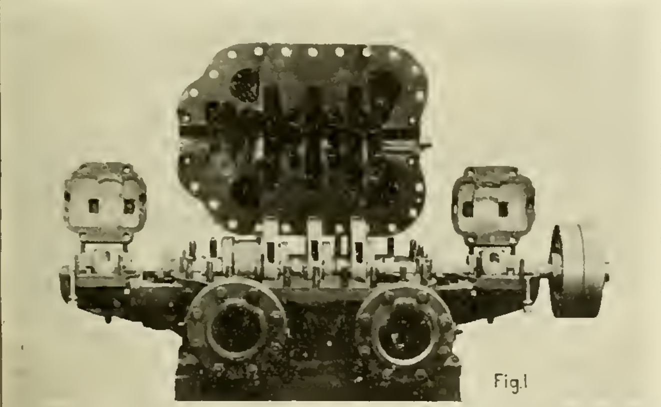

Fig.1

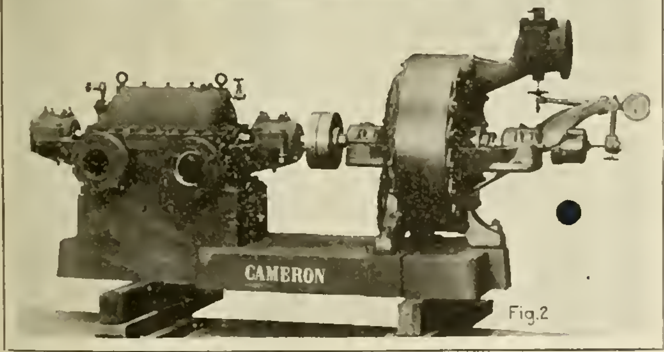

Fig.2

Fig. 1—Sectional View of Three-Stage Centrifugal Pump.
Fig. 2—Assembled Steam Turbine and Centrifugal Pump.

Figure 1 clearly shows the construction of one of these three-stage pumps. The high speed feature is a virtue of impeller design. With the ordinary impeller the diameter cannot be reduced sufficiently to get high speed without sacrificing vane length, and, consequently, efficiency for a certain vane length is very necessary in order that the impeller may perform its function without excessive loss. Small external diameter and adequate vane length are obtained in this pump, by bringing the vanes well down into the impeller hub, at the same time so turning them that the incoming water is guided smoothly, and with little loss into the outer portion of the vanes where the velocity is generated that is finally converted into useful pressure by means of the external diffusion vane. Additional advantages in the small impeller are light weight and low fibre stresses in the material.

The casing is divided along the horizontal centerline. Both the suction and discharge connections are in the lower half of the casing. The upper half is readily removable, giving full access to the revolving element. There are suitable openings for draining the pump and for displacing the air when starting. Inlet and outlet nozzles can be arranged either on the same or opposite sides—an important advantage where pumps are installed in limited space.

The shaft is made of high-grade forged steel accurately machined and ground, and wherever it comes in contact with the fluid being pumped, it is thoroughly protected by bronze sleeves, which prevent the stuffing box packing from scoring the surface of the shaft.

Each impeller is cast solid in one piece and is of the enclosed type. Surrounding each impeller hub is a pair of rings—one stationary, attached to the casing, and one revolving, attached to the impeller. By the use of double rings instead of a single ring it is possible to restore the initial tightness of the joint between the low and high pressure sides of each stage without any fitting whatever, whereas a new single ring would have to be of special diameters, and then fitted to the impeller hub, or the casing to make a tight joint.

The diffusion ring surrounds the impeller at its periphery, although it is not in contact with it. It contains a series of openings, which receive the water from the impellers at high velocity, and by means of gradually increasing area towards the periphery, reduce the velocity into pressure and enable it to advance to the entrance to the next impeller with much less loss of energy than would be the case if the high velocity of ejection were maintained.

To take care of thrust, which manifests itself in all multi-stage pumps, this pump is equipped with a simple internal hydraulic balancing device. This device consists of a revolving disc attached to the shaft at the inboard or high pressure end. Opposite this disc is a stationary drum of the same diameter. Water at high pressure connects with the space between the disc and the drum, causing the disc to react against the opposing thrust, neutralizing it and holding the rotor in proper relation to the casing. The slight leakage involved in this process is piped back to the suction.

On this pump, there are two ring-oiled bearings, self-aligning, one located on each side of the casing. The bearing bodies are horizontally split, with removable caps, and the bushings are also split and lined with high grade bearing metal. Bushings and bearings bodies have a spherical fit, automatically maintaining the alignment of the shaft. The bearings are of ample proportions to prevent heating, and the oil chamber is of liberal capacity. The bearings are supported by strongly ribbed brackets, cast integral with the lower casing, thus counteracting any possible tendency towards even slight vibration. These brackets are located sufficiently distant from the stuffing boxes to permit of adjustment of the glands. Felt washers are provided to prevent oil escaping from the bearings.

The stuffing boxes are deep and provided with water seals, consisting of a lantern gland in each box, connected to the water from the discharge side of the pump, through a concealed passage, so arranged that it can be readily cleaned. The stuffing box gland is fitted with swing bolts to give quick and easy access to the stuffing box.

When the pump is direct-connected, it is supplied with a shaft coupling of the flexible type, to compensate for slight variation in alignment.

The bedplate under the pump is of one-piece box construction heavy enough to give a rigid support, and with cross ribs to prevent distortion.

Figure 2 shows this pump entirely assembled, and it is claimed by the manufacturers that it occupies less space than the ordinary boiler feed pump of this general type, and that it will give a much higher degree of efficiency.

## REVENUE AND OPERATING EXPENSE OF MUNICIPALLY OWNED WATER WORKS IN MASSACHUSETTS FOR THE YEAR 1913.*

There has recently appeared from the State Bureau of Statistics the Eighth Annual Report of the Statistics of Municipal Finances covering the year 1913 (that is, fiscal years ending between Nov. 30, 1913, and April 1, 1914). This report contains in considerable detail the figures indicating the financial transactions of all the cities and towns in the commonwealth. Those for water works systems are not grouped by themselves, but are given in the general tabulations under the heading "Public Service Enterprises." The gross amounts contained in these tables are of little significance in themselves and cannot readily be compared with those of other cities and towns, except those appearing on the adjoining pages of the report.

In order to obtain really significant data from these figures, the writer has abstracted the figures of revenue and operating expense for all the cities and towns having municipal water works and has computed the per capita revenue and expenses, using population estimated on the basis of the 1910 and 1915 census figures. The results are given in the three tables accompanying, where Table I contains the statistics of the 36 cities; Table II, those of the 52 towns having a population of 5,000 or over; and Table III, those of the 47 towns having a population of less than 5,000.

It should be noted that in substantially if not absolutely all cases, the figures reported are based on cash receipts and expenditures and not necessarily on the true earnings and expenses for the year under consideration. It is also to be remembered in comparing these figures with similar figures for privately owned water works systems that in but few of the municipally owned plants does the water works receive any revenue for fire protection or hydrant service, and that in no case except Holyoke does the water department pay taxes. It must also be borne in mind that in a very large number of cases, particularly in the small towns, the administrative machinery of the town is utilized for the benefit of the water works without compensation out of water revenue—thus town treasurers or collectors of taxes in a great many cases render and collect the bills for water, the office and possibly the shop of the water department is in the town hall, and it may be in some cases that one of the selectmen or some other town officer acts as superintendent without additional compensation, or, at most, with very slight compensation from the water department.

Tables I and II, relating to the cities and the larger

TABLE I.—GROSS WATER WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS CITIES FOR THE YEAR 1913.

| Number. | City. | Population. | Gross Revenue per Capita. | Operating Expense per Capita. |
|---|---|---|---|---|
| 1 | Boston | 721,700 | $4.08 | $1.43 |
| 2 | Worcester | 156,012 | 2.86 | 0.60 |
| 3 | Fall River | 122,592 | 1.86 | 0.63 |
| 4 | Lowell | 107,405 | 1.82 | 1.31 |
| 5 | Cambridge | 107,230 | 3.57 | 1.12 |
| 6 | New Bedford | 101,400 | 2.66 | 0.81 |
| 7 | Springfield | 97,353 | 3.69 | 2.01 |
| 8 | Lynn | 93,215 | 3.34 | 1.64 |
| 9 | Lawrence | 88,511 | 1.53 | 0.71 |
| 10 | Somerville | 83,000 | 2.79 | 0.73 |
| 11 | Brockton | 60,124 | 2.45 | 0.91 |
| 12 | Holyoke | 59,580 | 2.16 | 1.66 |
| 13 | Haverhill | 47,316 | 2.72 | 0.85 |
| 14 | Malden | 46,500 | 2.27 | 0.73 |
| 15 | Newton | 41,789 | 3.42 | 0.96 |
| 16 | Salem | 39,800 | 3.05 | 1.27 |
| 17 | Chelsea | 39,037 | 3.20 | 0.67 |
| 18 | Fitchburg | 38,922 | 2.15 | 1.28 |
| 19 | Quincy | 37,460 | 3.26 | 0.68 |
| 20 | Pittsfield | 36,612 | 3.24 | 0.57 |
| 21 | Everett | 36,025 | 3.15 | 0.78 |
| 22 | Taunton | 35,399 | 2.67 | 1.26 |
| 23 | Waltham | 29,226 | 3.15 | 1.53 |
| 24 | Chicopee | 28,242 | 2.35 | 0.97 |
| 25 | Medford | 27,566 | 2.45 | 0.52 |
| 26 | Gloucester | 24,446 | 4.45 | 1.21 |
| 27 | Revere | 23,289 | 3.16 | 0.79 |
| 28 | North Adams | 22,028 | 2.79 | 0.41 |
| 29 | Beverly | 21,236 | 3.36 | 1.66 |
| 30 | Northampton | 20,766 | 2.95 | 0.96 |
| 31 | Leominster | 17,619 | 3.50 | 0.68 |
| 32 | Attleboro | 17,574 | 3.84 | 1.05 |
| 33 | Melrose | 16,411 | 2.72 | 1.13 |
| 34 | Woburn | 15,968 | 3.29 | 1.12 |
| 35 | Newburyport | 15,165 | 4.10 | 1.41 |
| 36 | Marlborough | 14,981 | 3.03 | 0.77 |
| Average |  | 69,299 | 3.16 | 1.14 |
| Maximum |  |  | 4.10 | 1.66 |
| Minimum |  |  | 1.53 | 0.41 |

Ratio of average operating expense to gross revenue = 36 per cent.

TABLE II.—GROSS WATER WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS TOWNS OVER 5,000 POPULATION FOR THE YEAR 1913.

| Number. | City. | Population. | Gross Revenue per Capita. | Operating Expense per Capita. |
|---|---|---|---|---|
| 1 | Brookline | 31,312 | $3.47 | $1.40 |
| 2 | Peabody | 17,464 | 5.60 | 1.59 |
| 3 | Westfield | 17,463 | 2.76 | 0.50 |
| 4 | Gardner | 15,704 | 3.97 | 1.14 |
| 5 | Watertown | 15,059 | 4.02 | 0.60 |
| 6 | Framingham | 14,691 | 4.52 | 1.31 |
| 7 | Weymouth | 13,540 | 3.66 | 0.85 |
| 8 | Arlington | 13,407 | 4.37 | 1.48 |
| 9 | Clinton | 13,144 | 2.58 | 0.80 |
| 10 | Methuen | 12,984 | 2.35 | 0.82 |
| 11 | Plymouth | 12,612 | 2.92 | 1.62 |
| 12 | Wakefield | 12,229 | 3.17 | 1.53 |
| 13 | Webster | 12,142 | 1.92 | 0.70 |
| 14 | Winthrop | 11,707 | 4.88 | 1.95 |
| 15 | Natick | 10,619 | 2.61 | 1.30 |
| 16 | West Springfield | 10,493 | 4.70 | 1.94 |
| 17 | Danvers | 10,469 | 3.69 | 0.94 |
| 18 | Winchester | 9,726 | 4.00 | 2.28 |
| 19 | North Attleboro | 9,463 | 2.94 | 1.28 |
| 20 | Saugus | 9,355 | 1.49 | 0.78 |
| 21 | Easthampton | 9,316 | 1.92 | 1.08 |
| 22 | Athol | 9,283 | 4.35 | 0.95 |
| 23 | Norwood | 9,193 | 3.63 | 1.36 |
| 24 | Ware | 9,116 | 1.33 | 0.97 |
| 25 | Amesbury | 9,084 | 3.75 | 1.05 |
| 26 | Braintree | 8,831 | 4.34 | 1.94 |
| 27 | Milton | 8,329 | 6.08 | 2.66 |
| 28 | Andover | 7,706 | 2.96 | 1.13 |
| 29 | Marblehead | 7,500 | 4.41 | 1.59 |
| 30 | Whitman | 7,430 | 2.54 | 1.39 |
| 31 | Stoneham | 7,330 | 3.20 | 1.29 |
| 32 | Belmont | 7,282 | 3.55 | 0.82 |
| 33 | Rockland | 7,015 | 2.94 | 1.91 |
| 34 | Swampscott | 6,888 | 5.90 | 2.31 |
| 35 | Hudson | 6,752 | 2.26 | 0.29 |
| 36 | Stoughton | 6,715 | 2.31 | 0.86 |
| 37 | Maynard | 6,618 | 2.04 | 0.68 |
| 38 | Concord | 6,577 | 4.45 | 1.54 |
| 39 | Reading | 6,409 | 3.78 | 1.55 |
| 40 | Spencer | 6,293 | 1.86 | 0.30 |
| 41 | Franklin | 6,121 | 2.95 | 0.90 |
| 42 | Ipswich | 6,074 | 2.45 | 0.82 |
| 43 | Wellesley | 6,028 | 4.94 | 1.80 |
| 44 | Needham | 5,935 | 2.89 | 1.29 |
| 45 | Winchendon | 5,816 | 2.53 | 0.89 |
| 46 | North Andover | 5,784 | 2.07 | 1.12 |
| 47 | Westboro | 5,734 | 1.94 | 0.74 |
| 48 | Abington | 5,569 | 3.18 | 1.57 |
| 49 | Orange | 5,340 | 2.69 | 0.93 |
| 50 | Canton | 5,292 | 2.94 | 1.85 |
| 51 | Lexington | 5,290 | 5.00 | 1.26 |
| 52 | Walpole | 5,252 | 3.93 | 2.15 |
| Average |  | 9,529 | 3.43 | 1.24 |
| Maximum |  |  | 6.08 | 2.66 |
| Minimum |  |  | 1.33 | 0.29 |

Ratio of average operating expense to gross revenue = 36 per cent.

TABLE III.—GROSS WATER WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS TOWNS UNDER 5,000 POPULATION FOR THE YEAR 1913.

| Number. | City. | Population. | Gross Revenue per Capita. | Operating Expense per Capita. |
|---|---|---|---|---|
| 1 | Monson | 4,905 | $1.40 | $0.32 |
| 2 | Uxbridge | 4,821 | 2.77 | 1.24 |
| 3 | Randolph | 4,562 | 2.38 | 1.09 |
| 4 | Dudley | 4,330 | 2.07 | 0.72 |
| 5 | Provincetown | 4,324 | 2.25 | 1.12 |
| 6 | Rockport | 4,295 | 3.85 | 2.39 |
| 7 | Agawam | 4,134 | 0.58 | 0.36 |
| 8 | Templeton | 3,951 | 1.72 | 1.33 |
| 9 | Falmouth | 3,609 | 7.66 | 2.73 |
| 10 | East Bridgewater | 3,558 | 1.40 | 0.48 |
| 11 | Barre | 3,269 | 1.18 | 0.24 |
| 12 | Billerica | 3,062 | 2.47 | 1.56 |
| 13 | North Brookfield | 2,997 | 2.52 | 1.36 |
| 14 | Holbrook | 2,894 | 3.52 | 1.48 |
| 15 | [illegible]pperell | 2,884 | 3.20 | 1.24 |
| 16 | [illegible]nchester | 2,835 | 6.47 | 4.70 |
| 17 | Ayer | 2,789 | 3.18 | 1.28 |
| 18 | Medway | 2,786 | 2.45 | 0.69 |
| 19 | West Bridgewater | 2,537 | 3.24 | 0.69 |
| 20 | Lancaster | 2,536 | 3.72 | 2.55 |
| 21 | Kingston | 2,526 | 2.45 | 0.96 |
| 22 | Hopkinton | 2,467 | 1.38 | 1.19 |
| 23 | Sharon | 2,406 | 3.96 | 1.36 |
| 24 | Hatfield | 2,387 | 1.92 | 0.17 |
| 25 | Holden | 2,366 | 1.90 | 0.08 |
| 26 | Douglas | 2,167 | 1.02 | 0.74 |
| 27 | Wrentham | 2,145 | 2.46 | 1.04 |
| 28 | Merrimac | 2,142 | 2.55 | 1.51 |
| 29 | Williamsburg | 2,123 | 1.52 | 0.48 |
| 30 | Brookfield | 2,117 | 1.10 | 0.60 |
| 31 | Avon | 2,103 | 2.33 | 1.43 |
| 32 | Wayland | 2,101 | 1.40 | 0.78 |
| 33 | Ashburnham | 2,077 | 1.70 | 1.65 |
| 34 | Ashland | 1,877 | 2.50 | 1.19 |
| 35 | Rutland | 1,833 | 2.19 | 1.11 |
| 36 | Northboro | 1,764 | 2.86 | 0.70 |
| 37 | Longmeadow | 1,504 | 3.05 | 2.04 |
| 38 | Marion | 1,475 | 5.66 | 3.35 |
| 39 | Millis | 1,426 | 2.36 | 1.27 |
| 40 | Plainville | 1,400 | 1.65 | 1.22 |
| 41 | Bedford | 1,312 | 2.70 | 0.92 |
| 42 | Nahant | 1,307 | 8.85 | 4.40 |
| 43 | Mattapoisett | 1,305 | 1.68 | 1.30 |
| 44 | Tisbury | 1,274 | 10.40 | 5.70 |
| 45 | Lincoln | 1,256 | 9.72 | 3.60 |
| 46 | Littleton | 1,229 | 2.50 | 1.32 |
| 47 | Russell | 1,049 | 1.38 | 1.52 |
| Average |  | 2,556 | 2.80 | 1.34 |
| Maximum |  |  | 10.40 | 5.70 |
| Minimum |  |  | 0.58 | 0.08 |

Ratio of average operating expense to gross revenue = 48 per cent.

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*A paper by Charles W. Sherman in the June, 1916, issue of the Journal of the New England Water Works Association.

towns, represent long-established water works systems in which the development is substantially complete. That is to say, the water pipes reach substantially all parts of the communities and the number of people not supplied from the public works is insignificant. In the case of the smaller towns listed in Table III, however, the conditions are very different in many cases. Oftentimes these works supply only the thickly settled central portion of the town, while a considerable portion of the population living in outlying districts is not reached by the water works. In such cases per capita figures, based on the entire population, are obviously of comparatively slight significance and should be used with great caution. In other cases the works have been recently established and have not yet reached their full development, even in the districts supplied. In a few cases of summer resort communities the revenue and expenses are abnormally large for the permanent population and ought more properly to be based on the maximum or transient population, if trustworthy figures were available.

In the case of cities and towns in the Metropolitan Water District, it should be noted that the operating expense includes only so much of the Metropolitan assessment as relates to maintenance of the Metropolitan Water Works.

For the reasons set forth above, the averages for Table III are probably not of great significance. Those of Tables I and II are, however, probably fair indications of the per capita revenue and operating expenses to be expected of thoroughly developed municipal water works in this state. Local conditions, of course, have a very considerable effect, particularly upon the operating expense; and the extent to which funded debts have been retired and the amount of extensions to be paid for out of earnings in addition to meeting operating expense would largely affect the amount which should be assessed in gross revenue.

It is hoped that water commissioners and superintendents will find these figures of assistance, particularly in making it possible to compare the conditions in the works under their charge with those of other cities and towns where the conditions are more or less similar.

## LINING A STEEL CONDUIT WITH CEMENT GUN BALTIMORE WATER WORKS.

The conduit connected the new dam on the Gunpowder River with the old tunnel, and was 10 ft. in diameter and 2,555 ft. long, built of 7/16 in. steel plates. The steel pipe was encased in concrete 18 in. thick at the springing lines and 8 in. thick at the crown, and was lined with reinforce mortar 1½ in. thick inside of joints. The following excerpt from the report of P. A. Beatty, Division Engineer, describes the method of placing the mortar lining:

The contractors elected to use the cement gun on the lining, and were directed by the Water Board to use reinforcement, as provided for in the specifications, the mortar to be 1:2 mix, 1½ in. thick over inside courses, and 1 15/16 in. over outside courses. The reinforcement was No. 7 wire mesh, American Wire Co. The New York Cement Gun Co. was given this sub-contract at 14.4 ct. per square foot, including the reinforcement.

The installation consisted of a steam-driven compressor of 500 cu. ft. capacity and two gasoline-driven compressors of 250 cu. ft. capacity each. A 2-in. air line carried the pressure to two F. D. cement guns of 2 cu. ft. capacity.

The cement gun delivers cement and sand, previously mixed and placed in the receiving chamber, through a hose to a ½-in. to ¾-in. nozzle, where water is sprayed on; the mortar being then discharged at a nozzle pressure of from 35 to 45 lb. per square inch against the surface to be covered. The sand and cement are first passed through an ⅛-in. screen. The weight of a cubic foot of 1:2 "gunite," as the product is called, shot into a form, is 124.2 lb., as against a weight of 122.6 lb. for one cubic foot of 1:2 mortar poured.

The wire mesh, 5 ft. wide, was cut in sections of sufficient length to take in the pipe circumference with a sufficient bonding lap, which was made at the springing line on alternate sides of the pipe. The wire was held in place by flexible wooden strips, about 10 ft. long, set transverse to pipe axis, sprung and held in place by gas pipe telescoping rods held by set screws.

In shooting the invert, rings of mortar about 1 ft. wide were shot on a few feet apart and screeded to the proper thickness, the intermediate space being shot and screeded from the rings as soon as the latter hardened sufficiently. No difficulty was experienced in shooting the full thickness on the invert. The lining was carried about 1 ft. above the springing line.

On the arch similar rings were shot and screeded, and the intermediate spaces covered with about ¾ in. of "gunite." From 12 to 24 hours later the remainder was shot on and screeded from the rings.

Before the method above detailed was used it was found that in screeding a broad area the screeds had a tendency to tear the surface, producing cracks. Where there was much excess material, it was removed with a trowel. About 15 per cent of the surface had to be reshot to bring it to the proper gage, about 85 per cent being right, or somewhat too thick.

In shooting against the steel a very large percentage of the sand rebounded, until the remaining mortar formed a cushion ⅛ in. or more in thickness, after which all of the mortar adhered. This rebound was removed and a portion of it screened and used again.

In shooting the invert, great care had to be exercised to prevent the collecting of this rebound. It was picked up with trowels and thrown just ahead of the nozzle and incorporated into the lining, but the results were not satisfactory.

It was found that on shooting the rings, the full thickness of 1 15/16 in. could be shot at one time, but if a broad area of arch were shot to this thickness, it was likely to fall, particularly if screeded or troweled much. Troweling flushed the water to the surface, causing the lining to become soft and pasty; it ceased to "gunite" and became troweled mortar. Adhesion and compactness are probably best attained by not touching the lining after shooting.

A surface left without dressing is full of minor irregularities, like a nutmeg grater, and covered with a film or glaze and should form an admirable protection if left in this condition. In shooting adjacent to a finished section there was a considerable amount of spatter, which adhered firmly to the finished surface, forming a crust. It was very difficult to get it off without hammering, and this was considered undesirable. Adjacent sections of concrete should be hard set before any spatter is permitted to come on them, and this should be scraped off while green. It is questionable whether, when a surface to be covered later is spattered, it is necessary to clean it. It adheres firmly to the steel, being rich in cement, and forms a good base for the lining. Whether greater adhesion would be obtained by shooting over this, the writer cannot state. One advantage which the cement gun people claim is lost, however, and that is the cleaning of the surface by the sand blast action of sand contained in the mortar. Too much value should not, however, be attached to the efficiency of this cleaning, as it is probably not very high.

The work in October cost the contractor 15.89 ct. per square foot, a loss of 1.49 ct. per square foot. In November the cost was somewhat reduced. The total number of square feet on the contract was 76,000. From Oct. 27 to Nov. 1, inclusive, 9.103 sq. ft. were completed, or about 1,517 sq. ft. per day. The following are some estimated figures:

| | |
|---|---|
| Installation per foot | $0.02 |
| Wire per foot | .01 |
| Board and transportation per foot | .085 |
| Incidentals and superintendence per foot | .175 |
| Gas, oil and coal | .095 |
| Cement per bag | .40 |
| Sand per cubic foot | .06 |

The nozzle wears away rapidly, causing decreased efficiency. A black rubber lining has been successfully used, which wears from two days to one week in active service.

Owing to dust and smoke, the conditions within the conduit were unfavorable to good work and inspection. As a result, at a number of places on the invert, the coating showed imperfections, such as insufficient thickness, pockets of rebound and wire near the surface. Most of these were discovered by sounding with a hammer. These discoveries led to several most thorough and careful examinations, and wherever any weakness was discovered the lining was cut out and patched by hand. These imperfections were confined to a few feet breadth of the invert, the remainder of the work appearing entirely satisfactory.

Conclusions.—In the writer's opinion, the cement gun can be used to great advantage in the protection of metal, but does not lend itself well to such work as is described above. If the invert had been troweled over a width of about 4 to 6 ft. and allowed to become thoroughly hard, and if all of the rebound had been removed, and all spatter taken off while green, it is probable that no superior method of covering steel with mortar is available. There would always, however, be some trouble owing to the constricted space and darkness, which would render the cement gun here less efficient than on the outside.

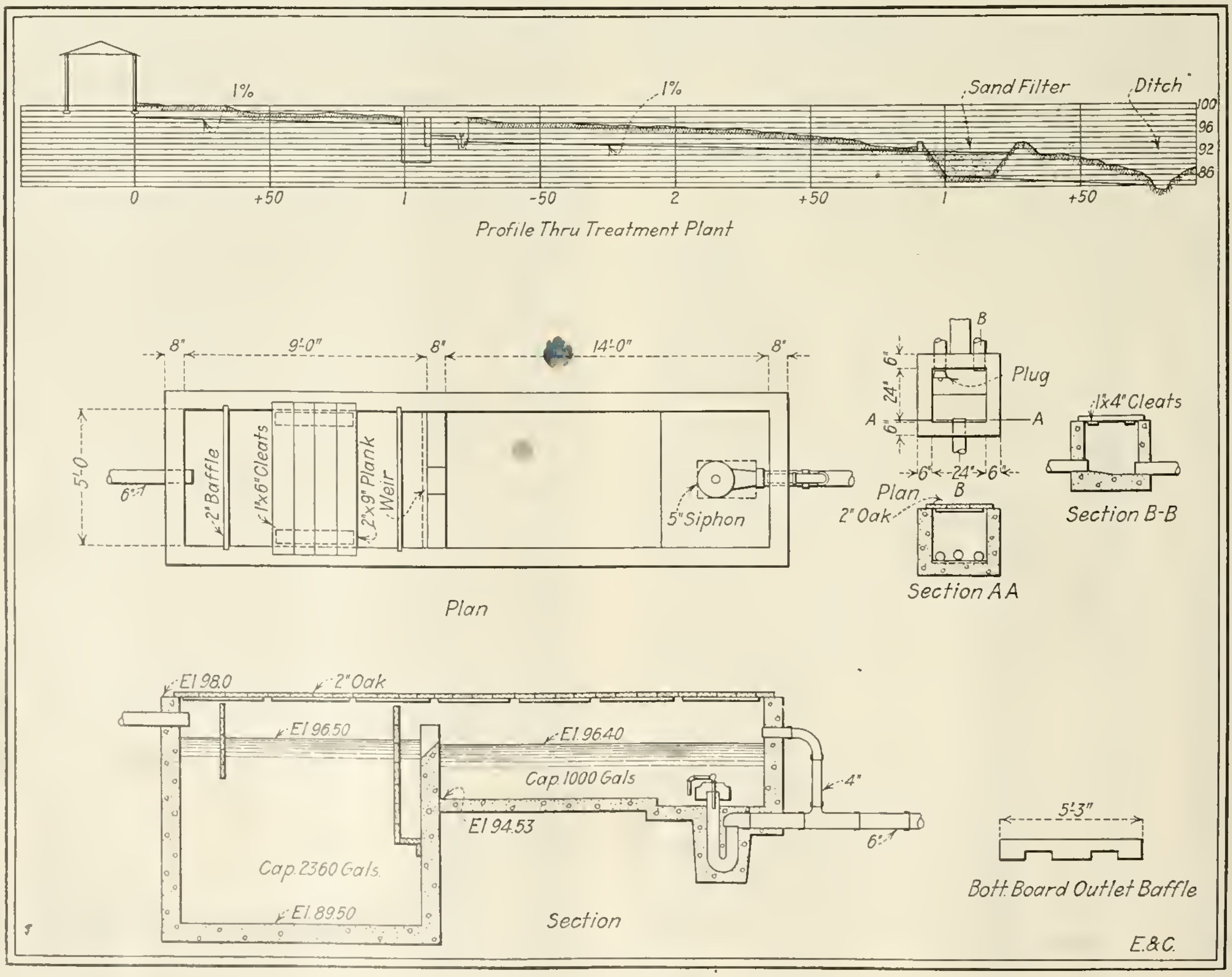
## SUGGESTED DESIGN OF DISPOSAL PLANT FOR CREAMERY OR CHEESE FACTORY WASTES.*

Where neither the raw nor the settled wastes can be disposed of by dilution alone, a butter factory making 1,000 lb. of butter daily or a cheese factory handling 1,250 gal. of milk per day, would require a waste treatment plant similar to that hereinafter described. The volume of wastes, with the exclusion of pure water, excess skimmed milk, buttermilk and whey, will be about 1,000 gal. per day. This will require a baffled settling tank of about 2,000 gal. capacity, a dosing tank of, say, 1,000 gal. capacity, and sand filters with a surface area of 1/25 acre or 1,742 sq. ft.

A suggested design for the plant is shown by the accompanying drawings.

**Settling Tank.**—The dimensions of the settling tank, in plan, are 5 ft. by 9 ft. and the depth below the flow line is 7 ft., making the total capacity of the tank 2,360 gal. The top of the tank is covered by means of a 2-in. oak cover constructed in removable panels 3 ft. in width. The lumber should be well seasoned and oiled or otherwise treated to prevent warping. Wooden baffles are placed at the influent and outlet ends of the tank to furnish the proper distribution and to prevent the scum which forms upon the surface of the liquid from being carried into the dosing chamber. These baffles are constructed of 2-in. cypress planks set in slots constructed in the sides of the settling tank. The effluent from the tank passes through two 4-in. by 12-in. slots in the bottom of the outlet baffle and enters the dosing chamber over a 12-in. concrete weir.

**Dosing Chamber.**—The dosing chamber is, in plan, 5 ft. by 14 ft. and has a total depth of 3 ft. 3 in. It is placed adjacent to the settling tank and is also provided with a 2-in. cover of well seasoned oak, prepared to prevent warping. One 5-in. siphon is placed in a sump at the outlet end of the chamber for the purpose of discharging the contents of the dosing chamber intermittently upon the surface of the sand filters. This siphon should be of some standard design in order to insure its continued satisfactory operation. It will discharge under a drawing depth of 23 in., which makes the total capacity of the tank 1,000 gal.



General Plan and Settling and Dosing Tank Details of Disposal Plant for Creamery Wastes.

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*From a paper by A. Elliott Kimberly, consulting engineer in Ohio Public Health Journal for July, 1916.

**Sand Filters.**—The 5-in. siphon in the dosing chamber discharges directly into a line of 6-in. vitrified sewer pipe, which leads to the influent chamber at the sand filters. This chamber is 24 in. by 24 in. and has a depth of 24 in. The outlets to this chamber consist of two 6-in. lines of vitrified pipe, which lead to stone aprons located upon the surface of the sand filters. This apron consists of large field stones or of No. 1 crushed stone, 4 ft. square and about 6 in. thick. Its function is to prevent a scouring of the sand at the end of the distributing tile and the formation of channels through the filtering material. Wooden plugs are provided at the influent chamber so that the flow from the spihon chamber may be discharged upon either of the sand beds. The filters, which are constructed in 2 units, are each 35 ft. 6 in. square at the sand surface. The sides of the excavation for the filters slope in the ratio of 1½ to 1. These slopes should be sodded above the sand line to prevent erosion. To simplify construction, the two units have been separated by a concrete wall rather than by an earthen embankment. The filtering material consists of 36 in. of filter sand supported by a layer of graded gravel. The filters are drained by two lines of 4-in. bell and spigot vitrified pipe (hard tile), in 2-ft. lengths laid with open joints, (¼-in. butt to socket), spaced 6 ft. each side of the center line. These drains have a slope of 1 to 40. The excavation of the bottoms of the filter slopes 1 to 80 in both directions from sides and center line to the drains. The drain lines are to be covered with graded gravel as follows:

Over the entire bottom, a layer of gravel, ranging in size from 1½ in. to 3 in., with a minimum thickness of 6 in. at the upper ends of the drain tile, next 2½ in. of ⅜-in. to ¾-in. gravel; next ¾-in. of 1/16-in. to ⅜-in. gravel, and finally, ½-in. of coarse sand. The sand, which forms the 3-ft. layer of filtering material, should be of good uniformity and should have an effective size of approximately .30 to .45 millimeters.

The main drain is a 6-in. vitrified bell and spigot pipe in 2-ft. lengths, laid on a minimum grade of 1 and 100, and connected to the 4-in. lateral drains by 6-in. by 4-in. single vitrified Tees.

**Cost.**—There are a number of local features which largely influence the cost of plants for treating the wastes of the dairy industry. These are particularly the availability of sand and gravel, the distance from the factory to the point at which the plant is to be located, the distance from the plant site to the stream and the fall from the factory drain. Pumping, of course, should be avoided where possible.

The cost of a plan capable of handling 1,000 gal. of butter factory or cheese factory wastes per day where complete treatment is required would range from $800 to $1,000. For condensory or skimming stations the cost will be slightly higher since the capacity of the settling tank should be increased one-third. Of the above cost, slightly more than one-half is that of the filtering material. Suitable bank or river sand if available a short distance from the proposed plant will somewhat reduce the above figures.

Where the flow of the adjacent stream permits the use of a tank alone, the cost of the treatment plant exclusive of the drain to and from the tanks would range from $100 to $200 for a plant handling 1,000 gal. of waste per day.

**Cost of Operation.**—The operating cost of treatment plants for wastes of the dairy industry are nominal. Raking the filters, cutting grass and weeds in and around the plant are the principal items of operation, together with that of changing daily the particular filter unit in service. In fact, so little labor is involved that no men are necessary in addition to the regular employes of the factory. From $10 to $20 annual expense may be incurred for removing scum or sludge from the tank.

## NOTES ON CONSTRUCTION AND USE OF FALSE BOTTOMS IN MECHANICAL FILTERS.[*]

**J. N. Chester.**[†]—We are strong believers in the false bottom, notwithstanding that fact that some of our most prominent sanitary engineers have in recent years condemned it, nor do we claim that it is original with either of us. It has been employed in filter design, to my knowledge, for more than thirty years, and it is our contention that it is the best means of securing an even distribution of wash water to the strainers, as well as removing the effluent from the strainers, for it reduces all currents to the minimum, and in addition provides ready access for cleaning, inspection and repair to this most troublesome part of filter construction.

**Thomas Fleming, Jr.**[‡]—Many filtration plants have suffered from an operating point of view due to a lack in proper facilities for thoroughly washing the filters. In the old types of filters, very little attention was paid to trough spacing and to the carrying height of water, but most of these filters were provided with mechanical rakes which thoroughly stirred up the sand during the washing period. When the modern concrete type of filter began to be adopted, agitation of the sand by compressed air was substituted for the old type of rakes and more attention was given to providing an adequate amount of wash water. This was limited usually to 8 gal. per square per minute, as it was found that a greater amount would disturb the gravel underlying the sand which was usually a small sized gravel ungraded and placed to a depth of eight or ten inches. Under these conditions and with the size of filter sand usually used, the trough system was placed at a height of 15 in., which was found sufficiently high to prevent the overflow of sand. More recent experiments have shown that a more effective wash can be obtained by eliminating the mechanical agitation and cleaning the filter with a rate of wash of 15 gal. per square foot per minute, which is almost twice the rate formerly adopted. When a filter is washed at this rate, it is found that the entire sand bed is floated, the finer sand being lifted from 24 in. to 30 in. above the normal surface of the sand, and the wash troughs must therefore be constructed at this height. This system was first installed in the Cincinnati, Ohio, plant and gave great success, not only in thoroughly cleansing the filter, but in a lower operating cost and with a less amount of wash water. The trouble from the disturbing of the gravel was eliminated at Cincinanti by tying down the gravel to the bottom of the filter with a bronze screen. Recently it has been discovered that by grading the gravel and using a depth of from 15 in. to 24 in. and by controlling the flow

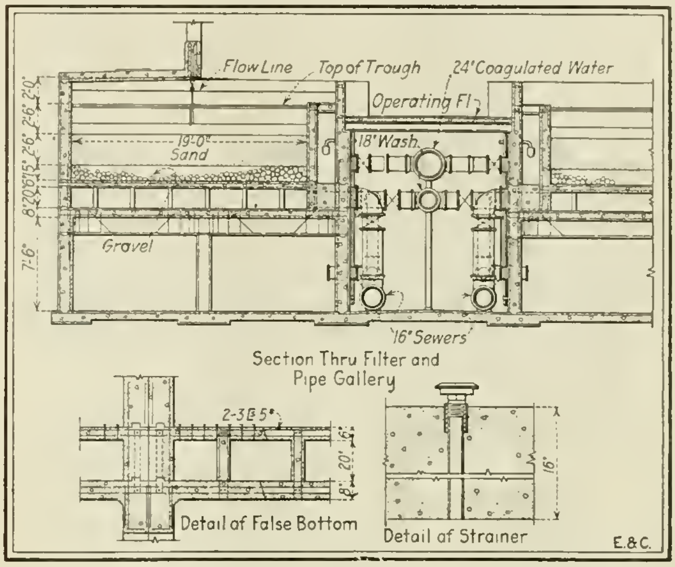

Fig. 1—False Bottom East Liverpool, O., Filter Plant.

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[*] Extracts from Proceedings, Engineers' Society of Western Pennsylvania, for January, 1916.

[†] Chester & Fleming, Engineers, Pittsburgh, Pa.

[‡] Chester & Fleming, Engineers, Pittsburgh, Pa.

of wash water so as to slowly and uniformly start and stop the wash, that it is unnecessary to tie down the gravel in the filters, and several of the latest installations have been installed on this basis.

As has been previously stated, the main problem with the hardwash system has been to distribute the wash water uniformly over the entire area of the bottom of the filter, and this seems to have been solved in the use of the false bottom arrangement at Alliance and Erie. At these plants a rate of wash as high as 20 gal. per square foot per minute has been handled with perfect distribution.

With some of the old types of steel filters, false bottom consisted of a steel plate 18 in. above the bottom of the filter in which the strainers were screwed and the space below this plate could be entered through a manhole on the exterior and inspected and cleaned without tearing up the entire filter. This false bottom has been applied to the newer type of reinforced concrete filters in the plants at Muncie, Ind.; Warren, Pa.; Shreveport, La.; Alliance, Ohio, and Erie, Pa. At the last two plants, it has been used in connection with the hardwash system and in all instances has given good results. In these plants, the false bottom consists of a ½-in. steel plate bolted to 8-in. I-beams spaced 2 ft. center to center and placed 18 in. above the bottom of the concrete filter to which they are bolted by columns and by anchor bolts. A manhole is provided for entrance to the bottom and at regular intervals, a filter unit is closed down, drained out, and entered and inspected, and if necessary, cleaned of any accumulation of sand. Under normal conditions, this false bottom is merely an addition to the clear water storage. The latest designs contemplate the construction of this entire false bottom of reinforced concrete. A plant with this type of construction has recently been completed by the Isthmian Canal Commission at Miraflores. The new 6,000,000-gal. plant now being installed for East Liverpool, Ohio, Fig. 1, will be of the same type.

**George C. Bunker.**§—In the opinion of the writer, the most important improvements in the art of rapid sand filtration are the developments of the concrete false bottom, reinforced in such a manner as to withstand the pressure developed by a high velocity wash, and the downward deflection of the wash water. The Miraflores purification plant, at Miraflores, Canal Zone, placed in operation in March, 1915, contains fourteen filters equipped with concrete false bottoms.

Each filter measures 19 ft. 9 in. by 21 ft. 6 in., which gives a sand area of 425 sq. ft. The total depth from the top of the walls to the true bottom is 14 ft., to the false bottom 11 ft. The normal elevation of the water in the filter is one foot below the top of the walls, which gives an average depth of 5 ft. 6 in. of water over the sand.

The floor or true bottom of each filter is 14 in. thick. Two feet above this floor is the reinforced concrete false bottom, one foot thick, which is supported by concrete pillars. In this are placed 1,677 vertical brass feed or strainer pipes, with inside and outside diameters of 11/32 and 17/32-in., respectively. They are spaced 6 in. apart, center to center, and above the top of the false bottom are bent over 180 degrees, with brass strainers screwed over the ends, so that the wash water is delivered directly upon the concrete instead of upwards into the gravel. The brass strainers, containing 25 holes, 1/16 in. in diameter, set about 1¼ in. above the false bottom.

The graded gravel is arranged in three layers; the bottom layer consists of 8 in. of the size that will pass a 1¾ in. and be retained on a 1-in. square mesh; the middle layer consists of 12 in. of the size that will pass a 1-in. and be retained on a ⅜-in. mesh; the top layer consists of 4 in. of the size between ⅜ in. and 3/16 in. diameter. Thirty inches of sand from a local beach, with an effective size and uniformity coefficient of 0.40 and 1.9, respectively, complete the filtering material.

A high velocity wash of 15 gal. per sq. ft. of sand surface consumes 6,400 gal. of wash per minute and develops a pressure of 16 lb. per square inch on the false bottom, which was designed to withstand a pressure of 28 lb. per square inch. The sand bed is raised 8¼ in. above its normal elevation. The relation between the area of the strainer openings and that of the sand surface of each unit is 1 to 475, or 0.21 per cent.

The strainers were not placed on the feed pipes in three of the filters. Washing at the above rate a pressure of 11 lb. per square inch is developed. After seven months' service these filters are in as good condition as the other eleven filters which are equipped with strainers. It is the opinion of the writer that a false bottom and 20 to 24 in. of gravel render strainers unnecessary.

Concrete filter troughs not only add to the appearance of a filter, but eliminate the constant scraping and painting of steel troughs. One large central and six lateral concrete troughs, measuring 24 and 13 in. wide inside, respectively, with edges 2½ in. thick, effectively remove the wash water. When washing at the rate of 15 gal. per square foot the depth of water over the weirs is 1¾ in. By means of weirs cut into the troughs the maximum travel of the suspended particles is limited to 2.5 ft., and there is sufficient current at the filter wall ends of the lateral troughs to prevent their settling out. In the construction of concrete troughs it is necessary that the upper surfaces of the edges shall be level both lengthwise and crosswise.

## QUANTITY OF GASOLINE NECESSARY TO PRODUCE EXPLOSIVE CONDITIONS IN SEWERS.*

The sewer tested was 8¼ ft. wide and 8½ ft. high and 2,706 ft. long with six manholes spaced 553.3 ft., 482.7 ft., 655.3 ft., 485.95 ft. and 477.7 ft. The velocity of flow was 6.45 lin. ft. per second, the depth of flow was about 8 in. and the volume of flow was about 19.6 sec. ft. Three tests of gasoline impregnation were made.

**Test I.**—A barrel, 55 gal., of refining gasoline was emptied into manhole No. 1, and samples of air were taken from other manholes at regular intervals for upward of two hours. The comment on the results follows:

One gallon of gasoline if entirely vaporized produces about 32 cu. ft. of vapor at ordinary temperature and pressure. If 1.5 per cent of gasoline be adopted as the low explosive limit of mixtures of gasoline vapor and air, 55 gal. of gasoline would produce enough vapor to render explosive the air in 1,900 lin. ft. of a 9-ft. sewer, provided the sewer air and the gasoline vapor were perfectly mixed. It will be noted how far theoretical conditions differ from the conditions of the test, as follows: First, the gasoline flowing with the sewer water was rapidly carried past any particular point; second, only the lighter parts had a chance to evaporate at any point; and, third, gasoline vapor is about three times as heavy as air, so that mixing of vapor with air at an appreciable distance above the sewer water would be slow. Sample 1 from manhole 2, taken two minutes after the introduction of the gasoline, contained 0.89 per cent of gasoline. Sample 1 from manhole 3 contained 2.19 per cent, and was taken three minutes after the gasoline had been poured in. In other words, the relation between the movement of the gasoline down the sewer, the distance between the manholes, and the time of collection of samples was such that at manhole 3 there was more gasoline vapor three minutes after the introduction than at manhole 2, two minutes after the gasoline had been poured in. The significant fact is that 2.19 per cent was the largest quantity of gasoline vapor in any sample. Only very small proportions were found at any manhole 10 minutes after the introduction of the gasoline. It is evident that 1 bbl. of gasoline (55 gal.) poured all at once in a manhole of a fast-flowing sewer renders the air explosive for only a few minutes at any particular point.

**Test II.**—The barrel of gasoline was poured into manhole No. 1 at the rate of 5 gal. per minute. Pouring in the gasoline required 11 minutes. Thirteen minutes after the inflow of gasoline had ceased there was, at manhole 2, 2 in. above the water, 1.14 per cent of the vapor. Eighteen minutes after the inflow of gasoline, only a trace of vapor was left in the sewer air at that point. At manhole 4 the gasoline vapor was not swept out so quickly. In 16 minutes the amount was 1.10 per cent (2 in. above), and in 31 minutes 0.12 per cent. At certain periods, 2 in. above the water, dangerous atmospheres existed, but in all instances 2 ft. above the water, the quantities discovered could not have propagated flame. Upon ignition of the gasoline at any time during a period of, say, 15 minutes after the gasoline had been dumped in a rapid sheet of flame would have swept along the sewer. The test shows, therefore, that 5 gal. of gasoline per minute introduced into the sewer under the conditions described would produce a dangerous condition as long as the flow lasted.

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§Physiologist of the Panama Canal, in charge of Purification of Water Supplies in Canal Zone, Gatun, C. Z.

*Extract from a report by G. A. Burrell and H. T. Boyd to the Bureau of Mines.

**Test III.**—A bulkhead was built to produce the conditions of a submerged outlet and the gasoline was poured at the rate of 1 gal. per minute into manhole No. 1. The results of the test prove that with a sewer submerged by high water extremely dangerous conditions can result from a small amount of gasoline. Between manhole 5 and manhole 6, a distance of about 500 ft., there was a dangerous condition five hours after the gasoline had been run in. The percentages of gasoline were slightly but noticeably increasing at manholes 3 and 4 above. It can be readily seen that if, as might happen, a sewer should be submerged for several days or a week at a time a highly dangerous condition would result if as much as 5 gal. of gasoline or light oil were to escape at one point from garages and dry-cleaning establishments or other places situated on its drainage basin.

**Summary.**—One barrel (55 gal.) of gasoline dumped at once into the sewer described caused the formation of an explosive mixture for a few minutes only at any given point. The explosive mixture was close to the surface of the sewer water and did not extend far into the upper sewer air.

When one barrel of gasoline was poured into the sewer at the rate of 5 gal. per minute the highest percentage of gasoline vapor 2 ft. above the sewer water was 0.70 per cent. The highest percentage of gasoline vapor (2 in. above the sewer water) was 1.67 per cent. This was found at manhole 3 6½ minutes after the gasoline had been dumped into the sewer. Thirteen minutes after the inflow of gasoline had ceased there was (No. 2 manhole) 1.14 per cent of vapor 2 in. above the water. Eighteen minutes after the gasoline inflow had ceased only a trace of gasoline vapor was left in the sewer air at manhole 3. At manhole 4 there was 0.12 per cent of vapor 31 minutes after the inflow had ceased. At certain periods of time, 2 in. above the water, explosive atmospheres existed, but 2 ft. above the water the atmospheres were not explosive. Upon ignition of the gasoline at any time during a period of, say, 15 minutes after the gasoline had been dumped in, a rapid sheet of flame would have swept along the sewer.

When the sewer was bulkheaded to parallel conditions such as would prevail if the sewer outlet were submerged a dangerous condition resulted from dumping into the sewer at one point one barrel (55 gal.) of gasoline at the rate of 5 gal. per minute. At some places there existed a dangerous atmosphere 5 hours after the gasoline had been dumped in.

When one-half barrel (27½ gal.) of gasoline was dumped into the sewer at the rate of 5 gal. per minute there did not result at any time a dangerous condition, except during the first 15 minutes, when, although no samples were collected, the air-gasoline mixture was unquestionably explosive.

Out of 6,553 tests of the air in sewers of the city of Pittsburgh, four, or about 0.06 per cent, contained as much as 0.4 to 0.7 per cent of gasoline vapor.

## POWER EQUIPMENT FOR THE BARGE CANAL SYSTEM OF THE STATE OF NEW YORK.

Contributed by C. H. MacCulloch, Resident Engineer, for the Publicity Department, Office of State Engineer, Albany, N. Y.

The Barge Canal system of the State of New York includes four canals: the Erie, stretching across the States from east to west, a distance of 343 miles, and joining the Hudson River with Lake Erie; the Champlain, extending in a northerly direction from the eastern end of the Erie Canal to Lake Champlain, a distance of 61 miles; the Oswego Canal, starting in a northerly direction from Three River Point on the Erie Canal and reaching Lake Ontario at Oswego, a distance of 23 miles; and the Cayuga and Seneca Canal, extending southerly from the Erie Canal a few miles west of Three River Point to Cayuga Lake and thence westerly to Seneca Lake, a distance of 27 miles, making a total length of 453 miles for the entire Barge Canal system.

There are 68 new locks in the Barge Canal system, distributed as follows:

| Type of lock. | Erie Canal. | Champlain Canal. | Oswego Canal. | Cayuga and Seneca Canal. | Total. |
|---|---|---|---|---|---|
| Standard | 36 | 11 | 7 | 4 | 58 |
| Guard | 2 | 0 | 0 | 0 | 2 |
| Junction | 6 | 2 | 0 | 0 | 8 |
| Total | | | | | 68 |

In addition four small locks were built on the old Black River Canal, an important water supply feeder of the Erie Canal.

Standard locks are 45 ft. wide and have an available length of 311 ft., a minimum depth of 12 ft. of water over the miter sill and vary in lift from 6 ft. to 40½ ft. The lock at Troy built by the Federal Government and the lock built for the Utica Terminal, are included in the 36 standard locks on the Erie Canal, listed above.

The two guard locks are located near Rochester, one on each side of the Genesee River crossing. These locks have lift gates which are operated only during periods when the water in the Genesee River is higher than normal pool elevation.

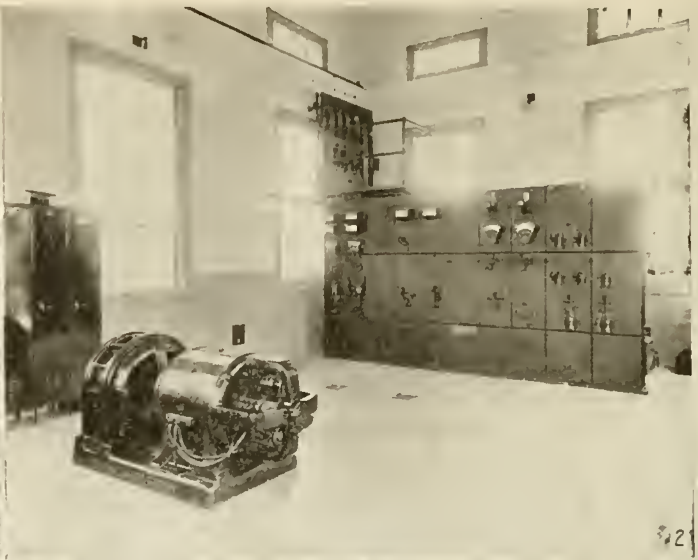
Junction locks are smaller than standard locks. They are not on the through route of the Barge Canal, but are at points where certain sections of the old canal enter the Barge Canal. These sections have to be maintained during the construction of the Barge Canal, so as not to interrupt traffic, or maintained continuously because they are water supply feeders as well as branch canals.

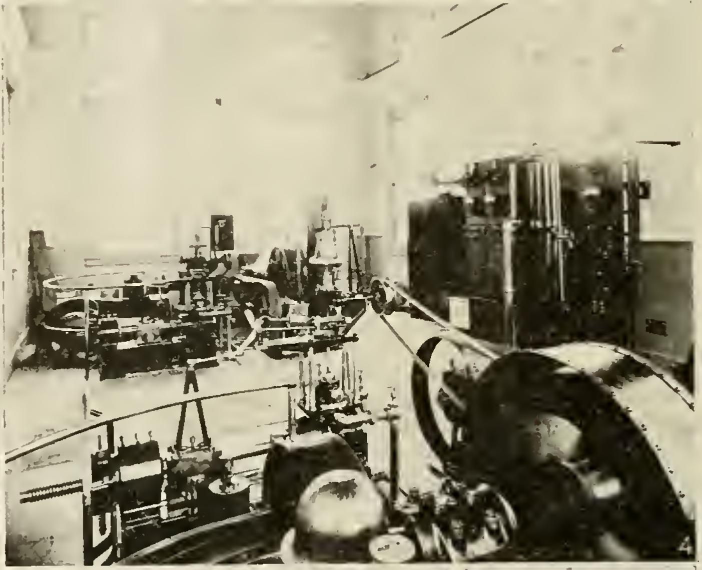
The description of power equipment which follows covers the equipment for 56 of the 58 standard locks, and the equipment of the two guards locks and the junction lock at New London. The remaining junction locks are not provided with power equipment. The equipment for the Troy lock built by the Federal Government is entirely different. The equipment for the standard lock at the Utica Terminal has not been installed. This equipment, however, will be the same as that used on other standard locks, and it is expected that this lock will be operated by power purchased from a local company.

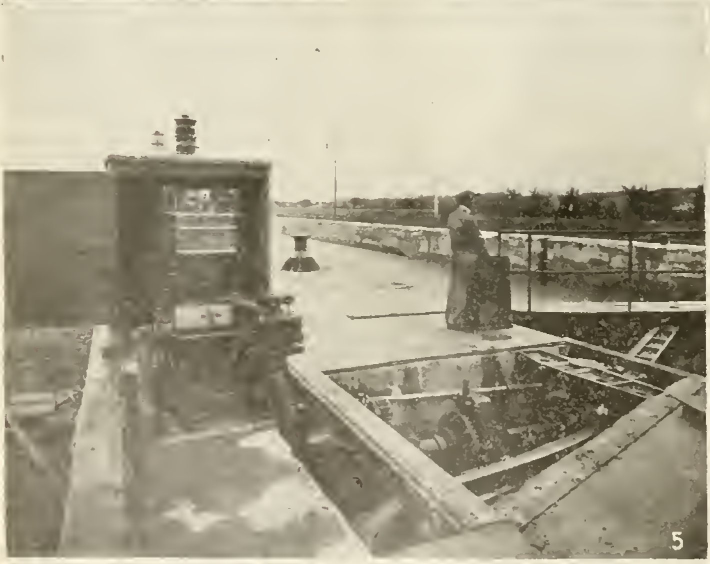
A head of water exists at each lock and in many instances it is necessary to by-pass a certain amount of water to take care of losses in the lower levels of the canal. By installing hydraulic turbines at these locks it is possible to develop power which otherwise would be wasted.

Locks are built of concrete and during the construction of many of these culverts and recesses for wheel pits were left in the masonry at practically no additional expense. This made the cost of a small direct current hydroelectric generating plant for each of these locks correspondingly less. Consideration, of course, was given to the construction of central alternating current generating stations with transmission lines connecting a number of locks, but it was found in all but one instance more economical to build a small direct current power plant at each lock, or at one lock of a group of two or three locks close together.

The one alternating current power station is located at







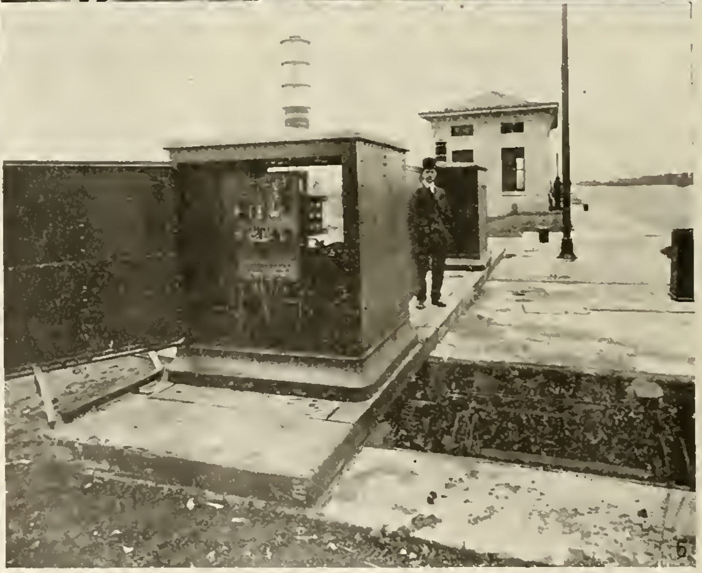


Fig 1—A Portion of the Waterford Flight of High Lift Locks, Showing Locks 4, 5 and 6, and Transmission Line. Fig. 2—Interior of Substation Lock 3, Erie Canal. Fig. 3—Interior of Typical Hydro-Electric Direct-Current Station with Vertical Shaft Generator Connected to Turbine Shafts. Fig. 4—Interior of Hydro-Electric Direct-Current Station with Horizontal Shaft Generator Driven Through Bevel Gears by Vertical Shaft Turbines. Fig. 5—Gate Operating Equipment. Cover Plates Removed and Cabinets Rolled Back. Lock Operators at Master Switch Stand. Fig. 6—Valve Operating Equipment. Cover Plates Over Valve Well Removed.

the east end of the Crescent dam on the Mohawk River and furnishes power for operating and lighting Locks 2, 3, 4, 5 and 6, and two guard gates on the Erie Canal. These five locks make up the greatest flight of high lift locks in the world, having a combined lift of 169 ft. (See Fig. 1.) With a dam already built, an abundance of water, and a comparatively large demand for power scattered over 2½ miles of canal, conditions were favorable for the construction of a central station equipped with alternating current apparatus. This station is about 50 ft. downstream from the dam on a bench cut in the rock and houses three 75 k.v.a., 2,300-volt, 3-phase, 40-cycle vertical generators direct connected to Francis inward-flow type turbines. Turbines are enclosed in steel cases connected to a 6-ft. penstock leading to a forebay in the dam. The discharge ring of each case is connected with the lower pool by means of a conical concrete draft tube formed in the concrete of the power house foundation. On the floor above are located the generators, oil pressure governors, stands for operating butterfly valves, motor driven governor pumps and switchboards.

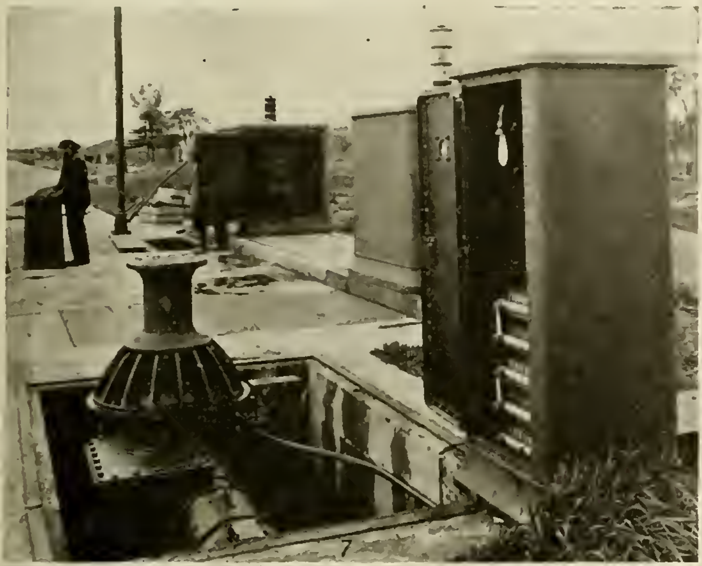
From this station 2,300-volt alternating current is transmitted by an overhead transmission line to three substations (Fig. 2), one at Lock 3, one at Lock 5, and one at the guard gate near the Mohawk River. At the substations, Locks 3 and 5, alternating current is converted to direct current at 250 volts by means of motor-generator sets and is then distributed to the nearby locks. The substation at the guard gate near the Mohawk River houses transformers, control panels and controllers for two 25-h.p. alternating current motors located on the guard gate superstructure. Poles for the transmission line are of reinforced concrete 30, 35 and 40 ft. long, and 8 in. square at the top with a uniform taper of 1 in. in 80 in. on each side. (See Fig. 1.)

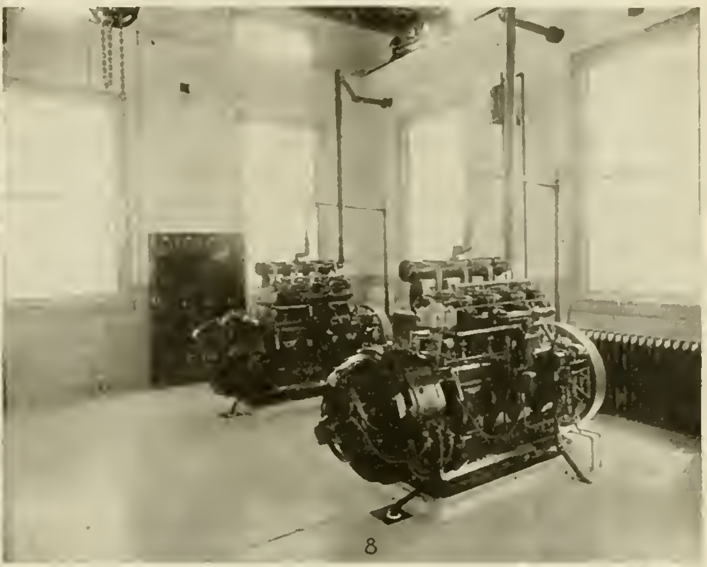
Power for 51 locks including the junction lock at New London is supplied by 31 direct current hydro-electric power stations and 11 direct current gasoline electric generating stations. At Lock No. 1 on the Oswego Canal, 3-phase, 25-cycle alternating current is purchased from the local power company and is converted to direct current at 250 volts by a motor-generator substation similar to those at Locks 3 and 5, Erie Canal.

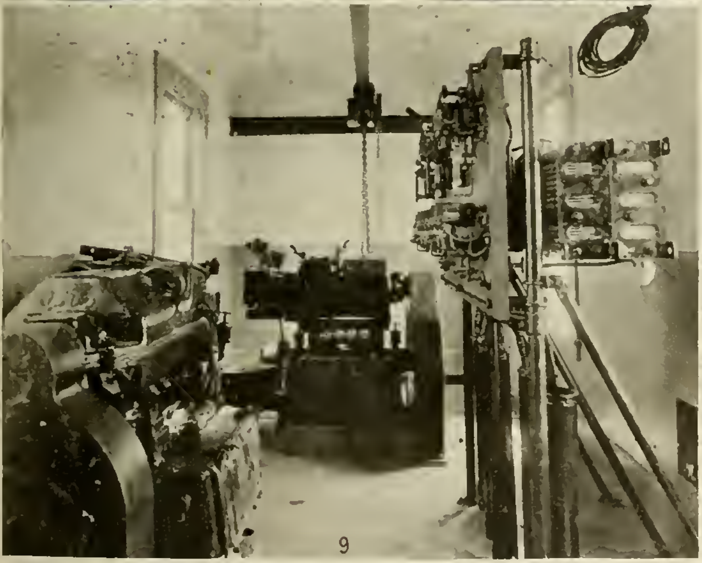
The hydro-electric stations are of two types, those having vertical shaft generators (see Fig. 3), and those having horizontal shaft generators (see Fig. 4).

On account of their large number, the direct current vertical shaft generator type may be considered as typical of Barge Canal power stations. The equipment for one of these stations consists of two head gates, two Francis inward flow type hydraulic turbines, each direct connected to a 50-k.w. 250-volt direct current generator, a switchboard consisting of two generator panels and one feeder panel, two motor driven governor oil pumps, two oil pressure governors, a motor driven oil pump and lubricating system, a traveling crane, four 4,000-watt electric heaters and an incandescent lighting system.

Slight variations from this type are necessary at certain locks on account of local conditions, if a power station feeds two locks, the capacity of the generator is increased to 75 k.w., and an extra feeder panel added; also, if the second lock is less than a mile or more than one-half mile distant, a booster set is provided, together with the necessary switchboard panel.







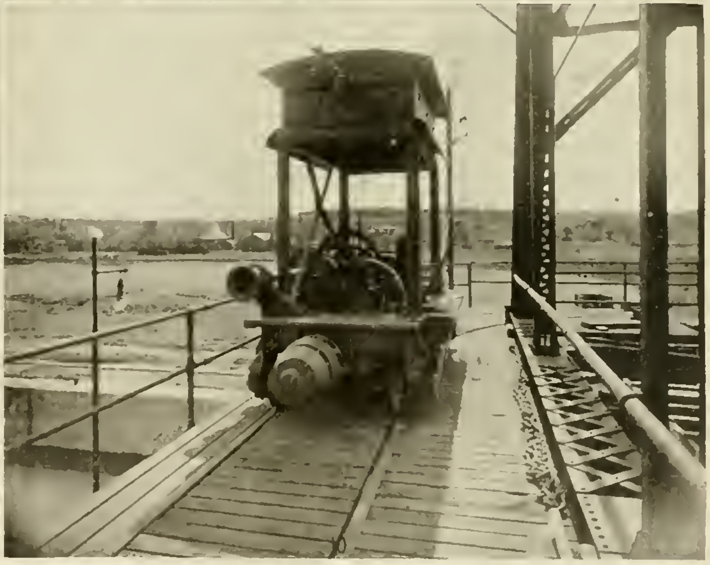


Fig. 7—Capstan Equipment. Cover Plates Removed. Fig. 8—Interior of Gasoline Electric Station. Fig. 9—Upper Story of Cabins Located Near Each Gate of Mohawk River Locks. Vertical Shafts and Bevel Gears Transmit Power to Machinery Located in Recess in the Lock Wall Below. Fig. 10—Movable Dam Winch. Trolley Wire Not in Place. Curtains Removed. Sections of Floor Between Rails Are Removed for Passing Chains During Operation.

There are five stations having horizontal shaft generators. Where the head of water is so low that the turbine speed falls below 150 r.p.m., horizontal shaft generators running at a full load speed of 300 r.p.m. are connected to the turbines through bevel gearing.

Head gates in the power culvert are made of yellow pine about 6 in. thick and carry on top a cast-iron weight sufficiently heavy to overcome buoyancy and the friction of the grooves in which the gate slides. These gates are operated by means of chains attached to the gates and chain hoists attached to the traveling crane. Gates cannot be raised until the water pressure on both sides is equal. In order to allow water to fill the wheel pit and equalize the pressure on both sides, the gate is so constructed that the cast iron portion can be raised about 3 in. before engaging upset bolts passing through the gate timbers. The turbines are Francis inward flow type with high speed cast iron runners. Wickets are connected by short links to a shifting ring supported by the curb plate of the wheel case, which in turn is connected by links to crank arms on the regulating shaft. The governor is directly connected to the regulating shaft.

To the crown plate of each turbine is bolted a three part lignum vitae steady bearing, the water load and weights of all rotating parts being carried by a roller thrust bearing located on top of the generator. The governors are of the familiar oil pressure type, of 6,000 ft.-lbs. capacity, and are designed to open or close the turbine gates in 1½ seconds. Except in stations having horizontal generators, governor oil pumps are motor driven. Two more driven pumps and one set of steel tanks are installed in each station. The capacity of one pump with tanks is sufficient for both governors when it is desired to operate generators in parallel.

Piping for governor oil system is of brass and the horizontal runs are carried in slots in the floor. These slots are covered with checkered plate. A belt connects the pulley of the fly ball element of the governor with a pulley on one end of a horizontal shaft projecting through the generator base. This shaft is driven through beveled gears by the vertical shaft of the generator. Generators are designed for direct current at 250 volts. They are compound wound and of the commutating pole type. The armature is supported by the roller thrust bearing mentioned above. This roller thrust bearing runs in oil, which is constantly fed from a distributing tank located on the crane rail ledge in one corner of the building. After flowing through the thrust bearing the oil passes to the steady bearing above the armature, thence in a pipe down between field coils through the lower steady bearing and bevel gear case to a filter, located in the basement. A small motor-driven gear pump pumps the oil from the filler to the distributing tank.

The switchboards are black marine finished slate, 1½ in. thick. At one side on a swinging bracket is an illuminated dial voltmeter. Generator panel equipment includes an automatic carbon break circuit breaker, one ammeter, four-point potential plug receptacle, one field rheostat and a triple pole single throw knife switch. Feeder panel equipment includes ground detector lamps and fused knife switches for the various motor circuits.

To facilitate the handling of apparatus in case of repairs or renewals, each station is equipped with a 3-ton capacity hand-power traveling crane. The bridge is a simple I-beam, on the lower flange of which travels a 4-wheel trolley carrying a chain hoist.

Each station is also supplied with the necessary lighting and heating equipment, a steel storage bin for tools, waste and oil cans and a 4-compartment steel locker.

All buildings are of reinforced concrete, with semi-glazed green tile roof covering. The roof is a concrete slab, 6 in. thick, on which is laid a 2-in. nailing medium covered with a layer of heavy asphaltum felt. The tile is laid on the felt and secured with bronze nails to the nailing medium beneath. Roofs are reinforced with wire cloth and are formed without girders or beams. The interiors are painted, floors and sidewalls to about 6 ft. above the floor drab, the remainder white, except for a 2-in. band of dark slate which separates the drab from the white. These buildings are severely plain, but are in harmony with their surroundings. (See Fig. 6.)

A canal lock is a very efficient type of hydraulic elevator. It consists of a deep oblong chamber with gates at each end. On the Barge Canal all but one of the locks have miter gates and in each side wall is a large culvert, the bottom of which is slightly higher than the invert of the lock chamber. Numerous small openings connect the culvert with the lock chamber. The culvert inlet is upstream from the upper gates. The outlet is downstream from the lower gates. Near each end of both culverts is a valve for the proper control of the water. These culverts are entirely independent of the culvert for supplying water to the turbines.

A lock is in readiness to receive a boat on its way upstream when the lower gates and valves stand open, and the upper gates and valves stand closed. As the boat enters the lock the lower valves are closed and when it is safely in the lock and lines attached to line hooks or snubbing posts, the lower gates are closed. The upper valves are then opened, allowing the water to enter from the upper pool into the culverts and out through the small openings into the lock chamber. The chamber gradually fills, lifting the boat until the water in the chamber is at the same level as the upper pool. The upper gates are then opened and the boat assisted in getting under way by the electric capstans. The lock is now ready to receive a boat on its way downstream. After this boat enters the chamber the upper valves and upper gates are closed and the boat made fast. The lock tender then opens the lower valves, thus allowing the water in the lock chamber to pass through the small openings in the side walls into the culverts and thence to the lower pool. The water in the chamber gradually drops until it is at the same level as the lower pool, then the lower gates are opened and the boat passes out. The time required for a lockage averages about 15 minutes.

Gates, valves and capstans are all electrically operated. Near each gate is a master switch stand. (See Fig. 5.) A simple movement of the hand will set in motion the machinery for opening or closing the gates and valves at one end of the lock. This can be done from either side of the lock. The master switch stand is made of cast iron, square in plan and about 3 ft. high. The top is a bronze plate, through which the shafts of five master switch cylinders project, one for each gate, one for each valve and one for the buffer beam. On the end of each shaft is a brass handle, which is moved to the right or left, depending on the position of the gate or valve. These stands are equipped with Yale locks, so that the handles cannot be operated by unauthorized persons. When turned to the right the master switch completes the circuit through the energizing coils of two contactors on the control panel, causing the motor to rotate in a clockwise direction. Turned to the left, two other contactors are energized, thereby closing the motor circuit for rotation in the opposite direction.

Once started the action of the motor is accelerating, running, de-accelerating and stopping is automatically taken care of by contactors and a drum type limit switch. Blocks of resistance are cut out and introduced in the circuit in such a way as to give a speed curve approximating a semi-ellipse. On the control panel is also located an overload relay, a reset coil, knife switches for the power and control circuits and ground detector lamps. Direct current at 230 volts at the motor is especially well adapted for the automatic control desired. This fact, coupled with the characteristics of the direct current motors and the simplicity of direct current apparatus, lead to the adoption of this type of equipment.

Control panels are located adjacent to the motors they control and are protected, together with the motor, limit switch and resistance units, by a large steel cabinet, as shown in the photograph.

The cabinets can be rolled away from the equipment they protect, thus offering easy access to any part of the apparatus. On top of the cabinets are signal lamps consisting of carbon filament incandescent lamps inside of cylindrical Fresnel lenses, 8 in. in diameter.

Signal lamps on the gate controller cabinets are red and green, indicating to lock tenders or boatmen the position of the gates. The red signal is displayed for all positions of the gate except when it is fully open. When fully open a green signal is displayed, indicating that a boat may approach the gates without danger of running into them. Signal lamps for valves consist of one blue and three white lights, the blue indicating that the valve is one-third closed, the white lights indicating the valve is one-third, two-thirds or fully open.

All motors are of the so-called rolling-mill type, totally enclosed and built with fireproof and moisture-proof insulation and specially treated to insure reasonable waterproofness. Each gate and valve motor is equipped with a self-adjusting solenoid brake having the same character of insulation as the motors.

A lock gate swings through an angle of 70 degrees. For a complete movement in either direction this takes about 1 minute. One end of the cast steel spar is attached to a steel pin in the gate, located about one-third the length of the gate from the center of rotation. (See Fig. 5.) The spar has teeth cut in one face, which mesh with a vertical pinion forming part of a train of gears driven by a 7-h.p. motor located on the lock wall. A buffer spring is housed in the outer end of the spar, to take up shocks. Bronze shear pins are provided in a coupling midway in the train of gears which are designed to break should the safe load on the machine be exceeded.

Most of the machinery is in a recess below the surface of the lock wall and is covered by checkered steel plates. The remainder, together with the electric equipment, is above the lock wall, protected by the controller cabinet. So located, the electric equipment is reasonably safe against damage, due to wash or floods.

In case of failure of the electric power, gate machines can be operated by hand. When this becomes necesary an interlocking lever located in the cabinet is thrown. This disconnects the motor, electrically and machanically, and throws in a jaw coupling of the hand-operating mechanism and uncovers a spindle which receives the socket of the hand sweep.

The culverts in the side walls of the locks are rectangular, 5x7 ft., 6x8 ft or 7x9 ft. in section, depending on the lift of the lock. Structural steel valves, having four large wheels and supported by two heavy crane chains which pass over cupped wheels near the top of the lock wall to a counter-weight, move vertically in the valve well across the culvert opening, thereby allowing water to pass through the culvert or shutting it off, as the case may be. The shaft supporting the cupped wheels is driven through a train of gears by a compound wound motor. (See Fig. 6.) This motor is rated at 3 H.P. for 5x7 ft. and 6x8 ft. valves, and 7 H.P. for 7x9 ft. valves. A part of the machinery is located in a recess in the lock wall and covered with checkered steel plates; the remainder is located in a cabinet near the back of the wall and in line with the cabinet for grate machines. Details of electrical equipment and machinery for hand operation are similar to those provided for the gates. Valve equipment are designed so that the valves can be raised or lowered at the rate of 6 ft. a minute.

At each end of each lock is an electric capstan of 8,000 pounds capacity at a speed of 60 ft. per minute. (See Fig. 7.) The diameter of the spool is 12 in. Except for the spool and the remote controller, the entire capstan is set in a recess in the lock wall and covered with checkered steel plates. The master switch is operated by a treadle set flush with the floor plates and conveniently located for the operator when overhauling a rope. Capstan machinery and its 20-H.P. compound wound motor are enclosed in a water-tight and oil-tight case. This equipment is designed so that it will not be damaged although submerged. The remote controller is similar to the gate and valve controllers, except in the detail of reversing contractors, which are not necesary for capstans.

On account of unusual conditions along the Mohawk River, the equipment at Locks 8 to 15, inclusive, Erie Canal, is different from the equipment at other locks. Adjacent to these locks are movable dams having Boule gates operated by electric winches. During the closed season of navigation these dams are raised and therefore a hydro-electric plant could not be depended upon, as under these conditions there is no head of water. A station was therefore built at each of these locks having two 25 K.W. gasoline electric generator sets, with a closed cooling system and incidental electrical apparatus. (See Fig. 8.)

During freshets in this section of the river these locks are sometimes several feet under water and during the spring break-up, ice passes over the tops of the locks. It is therefore necessary to protect electrical apparatus so that it will not be damaged by either ice or water.

A few feet back from the edge of the lock chamber and near each gate a concrete cabin was built on a heavy concrete base 9 ft. high. In this cabin the valve, gate and capstan electrical equipment is housed (See Fig. 9), and vertical shafts with the necesary bevel gearing transmits the power from the motors in the cabin to the machinery located in recesses in the lock below.

There are two electric winches for each dam. (See Fig. 10.) These winches travel on a track adjacent to the downstream truss. Each winch has a four-wheel structural steel truck and carries a horizontal shaft about 15 ft. long, having on each end cupped wheels to receive the chains for operating the gates and wickets. This shaft is driven through a train of gears by a 12-H.P. motor controlled by a standard drum type controller.

Gasoline electric stations were also built at Locks 25 and 26, Erie Canal, and at Lock 1, Cayuga and Seneca Canal, on account of conditions which made them the most economical for these locations.

Each lift gate of the two guard locks on the Erie Canal at the Genesee River crosing are operated by 2 20-H.P., three phase, 25 cycle mill type induction motors. The control panels and drum type controllers for operating these motors are housed in a steel cabinet at the foot of each tower. Power is purchased from the local power company. The concrete structure is similar to a standard lock except that it is 10 ft. wider, has lift gates instead of miter gates and a special arrangement of valves.

All locks on the canal are well illuminated, having on an average 10 750-watt nitrogen filled tungsten filament lamps per lock. Three lamps are placed on each side of the lock chamber, and two on the upper and two on the lower approach walls. Lamps are suspended from the mast arm of wrought iron poles and are 24 ft. above the elevation of the lock wall.

Except for the comparatively small amount of overhead transmission lines, all conductors are steel wire or steel tape armored, lead-covered rubber insulated conductors, laid 30 in. below the ground surface or lead covered, rubber-insulated conductors, carried under ground in metal duct or in fibre duct encased in concrete.

Locks which depend for their power supply on a station located at a distant lock are connected with the station by a telephone system. The five locks of the Waterford flight and the Crescent power station are equipped with an intercommunicated telephone system.

The cost of the complete operating and lighting equipment per lock, not including power station and station equipment averages $28,000. The cost of a typical hydro-electric power station complete averages $20,000.

## LIFE OF CAST IRON WATER PIPE OF THE HARTFORD, CONN., WATER WORKS.*

During the past year, new pipe has been laid in many streets formerly served by pipes laid many years ago. This action has been taken not because intrinsically the pipe had worn out or become useless, but solely because the community served is now a populous city district rather than a sparsely settled suburb. The iron in this old pipe was of excellent quality, and, except for the cost of salvage, it might well have been used elsewhere. The cost of removing these pipes, however, is usually found to exceed their value on account of other underground structures, street railway tracks, and improved street surfacing, to say nothing of the often very erratic alignment of the old layout. Some of the pipe is badly tuberculated and other partly filled with sediment, but if the pipe had not been too small for modern requirements in this district, it probably would have paid to clean it. So far as permanency goes, all of this pipe shows that cast iron is an ideal material for water pipes and that up to the present time no other substance has been found from which generally such satisfactory results can be obtained. There are three principal features to be considered in selecting water pipes—permanency, carrying capacity, and cost. Fifty-five to 60 years' service, and a condition such that life ahead cannot be estimated, certainly meets the first requirement. Well-laid clean or cleaned cast-iron pipes have a carrying capacity not greatly inferior to that of any other materials that have been used, and, if capitalized cost based on longevity of service is taken as a criterion, it appears that all these requirements for water pipes have been met.

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*Excerpt from a paper by C. M. Saville in Journal, New England Waterworks Association, June, 1916.

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## A SMALL MECHANICAL FILTER PLANT, WITH AUTOMATIC EQUIPMENT THROUGHOUT.

Contributed by E. E. Harper, Consulting Engineer, Kansas City, Mo.

Pleasanton, Kas., has a population of about 1,400, and about 1898 installed a water works system. The water supply is obtained from an impounding reservoir, and the water flows by gravity to the filter plant near the city.

The filter plant, as originally installed, consisted of one rectangular filter unit, 8 ft. square and about 8 ft. deep, built of concrete, and the mechanical equipment consisted of a strainer system, steel pipe laterals in the manifold system, a few valves, no gages or indicating devices of any kind, no rate controller. The chemicals were mixed in a small wooden tank, applied entirely by guesswork. There was no coagulating basin, the chemicals being applied to the water as it entered the filter. The water from the filter was stored in a circular, concrete lined basin, 72 ft. in diameter and 6 ft. deep, located about 40 ft. distant from the filter, subject to overflow during freshets, and not covered.

The foregoing description is given for the reason that it tells pretty well how a filter plant should not be built, and it is needless to say that the results obtained in the operation of such a plant were very bad.

In redesigning and rebuilding this plant the concrete work for the filter unit was utilized, but the mechanical equipment throughout was replaced with new equipment. A new coagulating basin was constructed, and the old storage basin for filtered water was relined and the walls raised 2 ft. so that the basin would not be flooded by freshets. The clear water basin, on account of its size, was not roofed.

The coagulating basin is circular in form, 30 ft. in diameter, 10 ft. deep, and is provided with a circular baffle wall so arranged that the water travels in a spiral course from the center of the basin toward the outside. This basin is, in the opinion of the writer, twice as large as is necessary to meet the local requirements, but was built to conform with the requirement of the Kansas State Board of Health, which has insisted on coagulat-

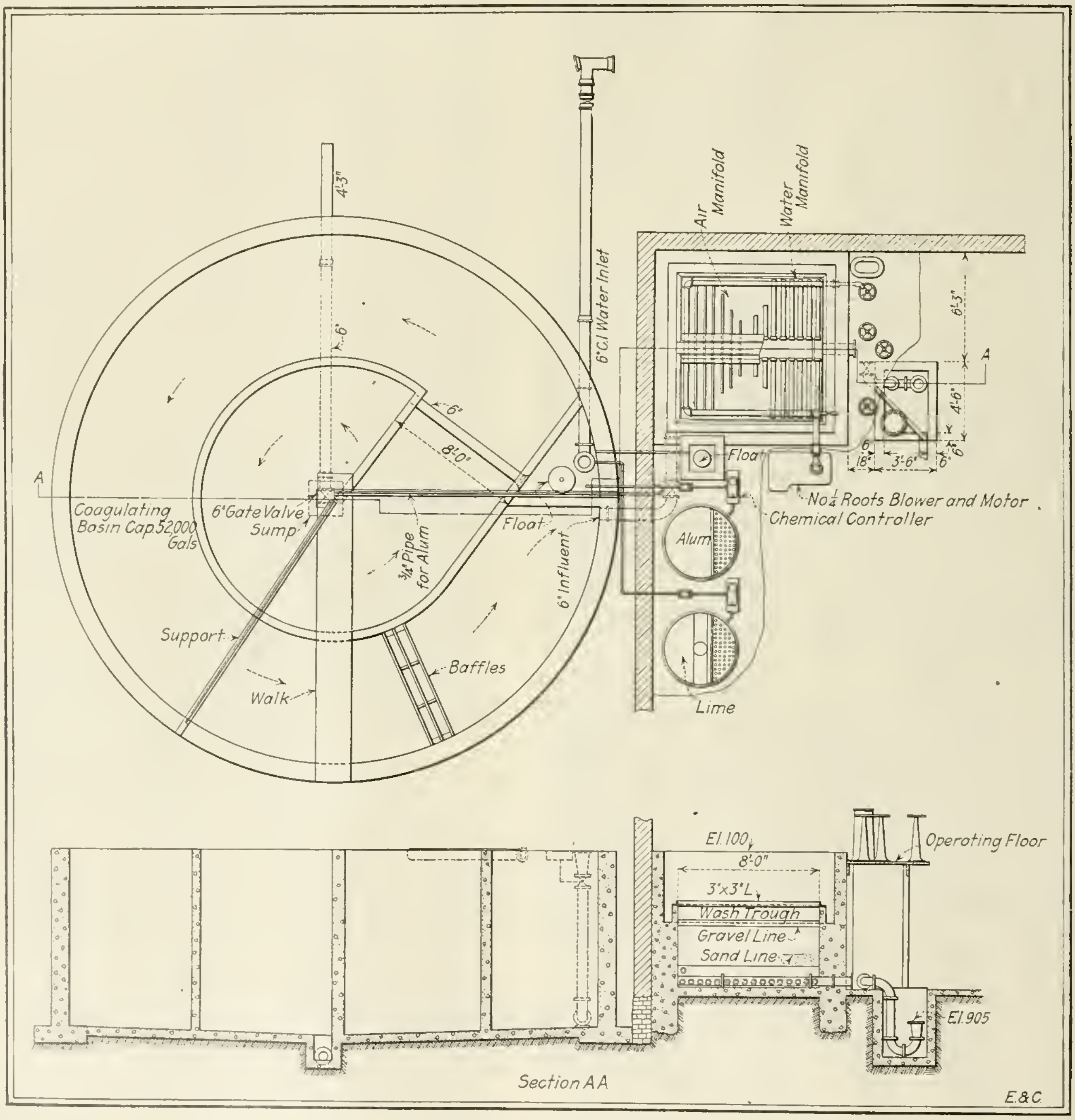

Fig. 1—General Arrangement of Filter Equipment at Pleasanton, Kansas.

ing basins having sufficient capacity for at least 6 hours' sedimentation.

The water from the impounding reservoir flows to this basin by gravity, and discharges through an orifice plate on the inlet pipe which rises to a height about 4 in. above the normal water level in the basin.

The head under which the water discharges through this orifice varies from zero to 9 in., depending on the rate at which the filter is operating, and this head is communicated by means of a pipe to a small float chamber inside the filter house, where any change in head is transmitted by means of a float, cable and pulleys to the proportional feed devices which feed the lime and alum solutions.

These devices are so arranged that the chemical solutions are discharged through suitable orifices under exactly the same head as the raw water is discharged through the orifice on the inlet to the basin, thus providing a proportional feed which is entirely automatic in its operation.

The water level in the coagulating basin is controlled by a float-actuated valve on the inlet pipe, and is level with the water in the filter.

Provision is made for applying the coagulants to the raw water at any point in its travel throughout the basin, but ordinarily the coagulants are added to the water just as it enters the basin.

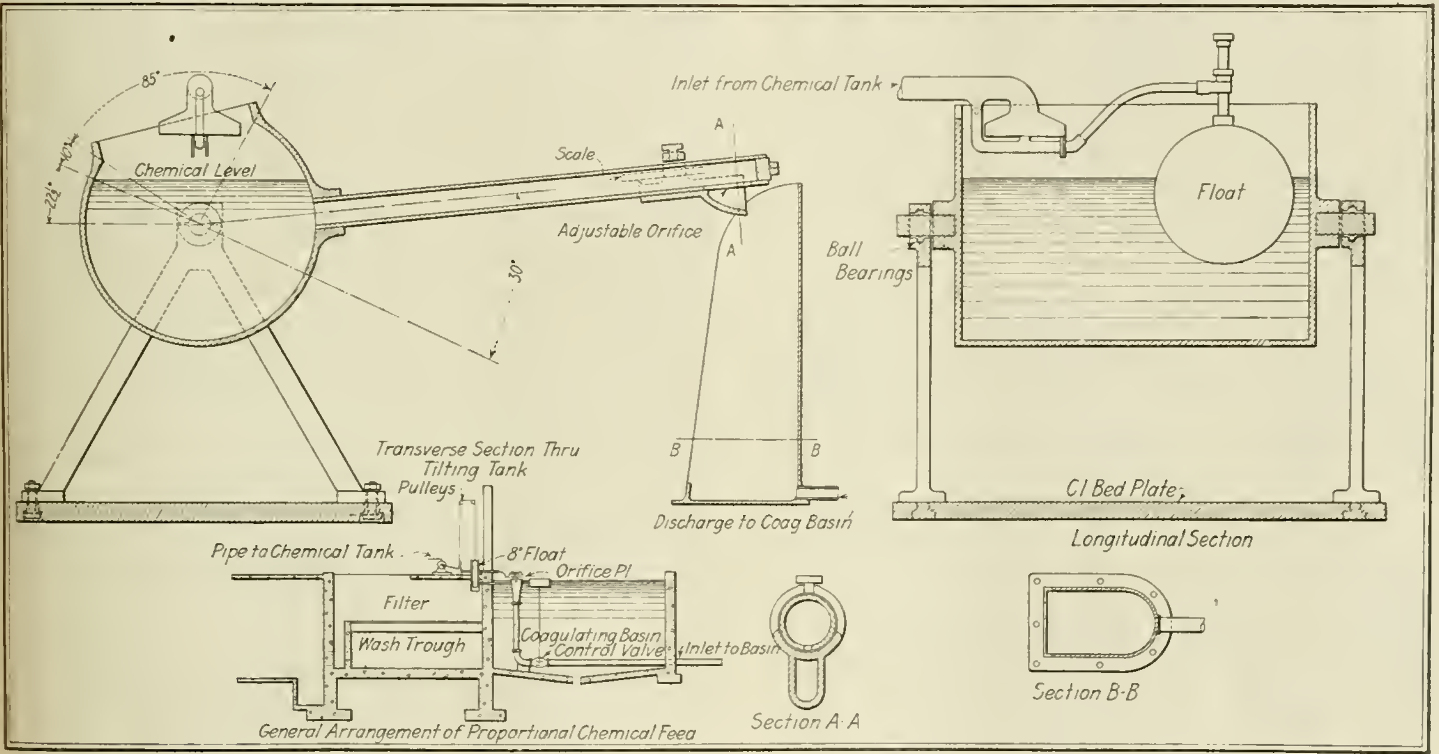

Fig. 2—General Arrangement of Proportional Chemical Feed and Details of Tilting Tank.

The filter unit is equipped with cast iron laterals, as it was found that the old steel laterals had rusted so badly that they would not hold the strainers. The controller which regulates the rate of filtration is of a comparatively new type, and operates on the principle of maintaining a constant head over an orifice, which, by means of a cone shaped piece can be increased or decreased in size when it is desired to change the rate of filtration.

This change in rate is accomplished by a handwheel on the operating floor, but under ordinary conditions the controller is set for the normal rate of flow, and maintains this rate until the clear water reservoir is filled to a pre-determined level, when the controller begins to throttle the discharge from the filter very slowly, and continues to do so until the water in the clear water reservoir rises about 9 in., when the controller completely shuts off the flow from the filter.

As soon as the water is lowered in the clear water reservoir by pumping, the filter automatically begins operation again.

At the present time the pumping is done by a steam pump, located at the filter plant, but it will only be a short time until a motor-driven pump is installed, with equipment for starting and stopping this pump from uptown, half a mile distant from the plant.

When this is done, the necessity of having a man on duty all day at the plant will be done away with, for all that will be necessary will be for the attendant to make an inspection of the plant say once each day, wash the filters when necessary, and make up a fresh supply of coagulants for each day.

The plant is equipped with a motor-driven blower for air wash, a hypochlorite plant for emergency use, and with mercury loss-of-head gages. It is the first plant in Kansas to have automatic equipment. The average daily consumption of water is about 50,000 gal.

The plant has been in operation long enough to demonstrate that the automatic devices can be depended upon to perform their work properly, and to show that they are of value in a small plant, for the reason that more uniform results are obtained, and the attendant can devote most of his time to other things, and there are always plenty of them in a small town to keep a man busy.

The plant was designed by E. E. Harper, Consulting Engineer of Kansas City, Mo., and the mechanical equipment of the filter plant was furnished and installed by the Pittsburgh Filter Mfg. Co.

## PRACTICE IN THE REMOVAL OF IRON FROM MUNICIPAL WATER SUPPLIES.*

While the number of iron-removal plants in the United States is small, the character of the water from which the iron is removed varies so widely that almost every method of iron removal may be found in practical operation.

The first deferrization plant in this country was built in 1890, at Asbury Park, N. J. The water was pumped directly from the wells to the filters, and the removal of iron was not complete because of a lack of sufficient aeration. At the present time this water is given partial aeration by being pumped into an open tank, and after an hour's sedimentation it is forced through a pressure filter. This filter consists of two tanks, one containing 6 in. of gravel and $2\frac{1}{2}$ ft. of sand; the other, 3 ft. of boneblack. The water passes through the sand filter first and then through the charcoal. The filter is operated at a rate of 5 gal. per square foot of filtering surface per minute. The raw water contains 1.1 p.p.m. iron, 97 per cent of which is removed by this treatment. A similar plant is in operation at Atlantic Highlands, N. J.

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*Extract from Engineering Bulletin No. 7, University of Kansas, by James W. Schwab, Lawrence, Kan.

An iron-removal plant has been in operation at Far Rockaway, N. Y., since 1896. The water, which contains about 2.4 p.p.m. iron, is partially aerated and then filtered. The method of aeration is simple. The pipe through which the raw water is brought to the filters stands vertically, with the open end several feet above the water. Sufficient oxygen is furnished to the water as it falls over the edge and down the sides of the pipe to the filter. Slow sand filters are used, and the iron removal is complete.

The water supply of the city of Urbana, Ill., contains about 2 p.p.m. of iron. Before the completion of an iron removal plant, in 1913, the water furnished was of a very poor quality, due mainly to growths of Crenothrix in the distribution system. At present the water supplied to the city is entirely satisfactory, the Crenothrix having disappeared from the mains. The water is pumped from the wells to a raw-water reservoir, where some aeration is obtained as it is discharged into the reservoir. From this reservoir the water is pumped to the filters. It is discharged into the filter through an orifice at the end of a vertical pipe, rising as a jet and dropping vertically to the surface of the water in the filter. As a result of this added aeration, the water is practically saturated with oxygen when it reaches the filter. No coagulants are added, since the precipitate of ferric hydroxide gives sufficient "floc" for the operation of the rapid sand filter. By this treatment 85 to 90 per cent of the iron is removed.

At Superior, Wis., water containing about 1.5 p.p.m. of iron is taken from wells sunk 40 ft. in the sand on the shores of the lake. Before the water was purified it supported growths of Crenothrix and ferric hydroxide precipitated in the mains. The original installation (1899) consisted of an aerator of the tray type, and a sand filter. The aerator was made up of two tiers of four trays each, the trays being spaced 2 ft. apart. The bottom tray was made of a steel plate ¼ in. thick, punched with ¼-in. holes. The water was delivered to the top trays and fell over the edge of these trays onto the ones immediately below them, and so on down, finally streaming through the perforated bottoms of the lower trays. This aerator was very efficient. It left the water saturated with oxygen and practically free from carbon dioxide. The aerated water was filtered at a high rate (ten to fifteen million gallons per acre per day) through slow sand filters. The treatment gave only fairly good results. The water no longer supported Crenothrix, and very little iron precipitated in the mains; but it had a pronounced color, and analyses showed almost 1 p.p.m. iron. In 1906 experiments were carried out by W. C. Lounsberry which showed that if the water were carried directly onto the filters, with no aeration aside from that due to leaky valves, the removal of iron was much more complete and the color was almost absent in the filtered water. Since that time the water has been filtered without aeration, and is entirely satisfactory. In this case carbon dioxide and very slight excess of dissolved oxygen are necessary to obtain results. The color is due probably to some obscure combination of iron which forms readily in the presence of oxygen if carbon dioxide is absent, or present only in very small amounts. Iron-removal plants using the same method that was first tried at Superior, Wis., are in operation at Red Bank, N. J.; Richmond, Mo.; Garrettsville, Ohio; Shelby, Ohio; and North Kansas City, Mo. A similar plant at Excelsior Springs, Mo., is in process of construction, and plans for another have been submitted to the city of Manhattan, Kan.

These plants differ chiefly in the construction of the [illegible] At Red Bank, N. J., the pipe carrying the water [illegible] stands vertically several feet above the water [illegible] the end of this pipe is closed. The sides are perforated with ¼-in. holes, the water being forced from these holes in jets, giving sufficient aeration.

The tray type of aerator is used at Richmond, Mo. Four trays, each 2 ft. by 6 ft. deep, are superimposed so that there is a vertical distance of 2 ft. between each tray. The bottoms of the trays are made of wire net, and support a galvanized iron plate punched with ⅛-in. holes spaced ½-in. apart. The water is delivered to the top tray and falls in thin streams through it and the lower trays. A similar aerator is in operation at Liberty, Mo.

Aeration is furnished at Garrettsvile, Ohio, where the water at the point of discharge into the settling basin falls from a vertical pipe over the edge of the pipe and down its sides onto an umbrella-shaped device 4 ft. in diameter. The water falls 5 ft. from the edges of the "umbrella" to the surface of the water in the settling basin.

The plans for the plant at Excelsior Springs, Mo., call for an aerator of the tray type. It differs from the one at Richmond, Mo., in that the water, instead of streaming through the perforated bottoms of the trays, falls in thin sheets from the edge of one tray to the tray below it.

In some cases the iron content of a water is of great assistance in the removal of color. This is the case at Miraflores, in the Panama Canal Zone. The supply is taken from Miraflores lake. The raw water contains 0.8 to 2.5 p.p.m. iron, is colored, and has an objectionable odor, due to the hydrogen sulphide gas formed by the decaying vegetable matter present. Very thorough aeration is necessary in order to eliminate the odors, and this treatment precipitates the iron. The coagulation of the ferric hydroxide helps in removing the color by reducing the amount of sulphate of aluminum which must be added to effect a complete removal. This assistance is vital in waters of low alkalinity and high color. The aeration is furnished by means of sprays. One hundred and five specially designed nozzles are spaced equally distant over an aeration basin 86 by 125 ft. in area. Water is forced from these nozzles with sufficient pressure to cause it to rise to a height of 15 to 20 ft. in the form of a very fine spray. After aeration the water is led into a baffled sedimentation basin, sulphate of alumina is added, and the water is passed through rapid sand filters.

In all of these cities, with the exception of Superior, Wis., no difficulty was experienced in causing the ferric hydroxide to precipitate when sufficient time was allowed for coagulation after aeration. This is not always the case. There are several water supplies in the United States which contain iron in such amounts that purification is necessary and in which iron will not coagulate after aeration. At the present time there are two methods of removal which have been successful in the treatment of such waters: lime and sulphate of aluminum may be added, or in most cases the coagulation may be brought about by a suitable period of contact with some rough material such as coke.

The city of Reading, Mass., is furnished with water originally containing about 9 p.p.m. iron, and which is secured from filter galleries placed in the water-bearing gravel in the banks of the Ipswich River. It contains also varying amounts of humus substances with which iron will combine under certain conditions, and this combination is not broken up by aeration, as it is formed more readily in the absence of carbon dioxide. Since the building of the filter galleries in 1890, various methods of purification have been tried. At the present time lime and sulphate of aluminum are used. The iron content is reduced from 9.4 p.p.m. to 0.05 p.p.m. by the addition of 0.9 pound of lime per 1,000 gal. and 2 to 2½ grains of sulphate of aluminum per gallon, followed by rapid filtration.

The water supply for the city of Colon, Panama, contains about 2 to 3 p.p.m. iron. The iron is held in suspension by the organic matter present in the water. Before the method now in use was adopted, this suspension of ferric hydroxide would rapidly clog the filters. To remedy this situation a coagulation basin was built, and the water was treated with 1 to 1.5 grains of aluminum sulphate per gallon. A great part of the aluminum hydroxide precipitates settles out, taking the iron with it. The work of the filters has been much more satisfactory, and the effluent is colorless and free from iron.

In many cases the action of those substances which interfere with the precipitation of iron from water may be neutralized by contact with a rough, porous material. This method of bringing about coagulation of the ferric hydroxide is the latest of the several methods of iron removal to be used in the United States.

In June, 1914, Mr. R. S. Weston published experimental results showing the action of contact with coke in removing iron from water in which organic matter and manganese acted as interfering substances. Results were given on waters from three New England cities, and in each case the iron was held in colloidal suspension by different substances. At Cohasset, Mass., organic matter kept the iron from coagulating after oxidation. Limited aeration, followed by a short period of submerged contact with coke, was shown experimentally to be the necessary treatment, and the period of submerged contact with coke varied with the season of the year. The effluent was filtered through sand.

At Brookline, Mass., both organic matter and manganese interfere with the precipitation of ferric hydroxide. In this case a satisfactory removal was effected by allowing the water to trickle through 10 ft. of coarse coke at a rate of 75,000,000 gal. per acre per day, followed by filtration through sand at the rate of 10,000,000 gal. per acre per day.

Manganese interfered at Middleboro, Mass. Satisfactory iron removal was impossible until conditions were such that manganese was removed along with the iron. This was brought about by completely aerating the water by trickling it through 10 ft. of coke. After a period of sedimentation the water was filtered. As a result of these experiments, a plant was installed for treating the entire supply.

An experimental plant was set up at Lowell, Mass., in 1913, to determine the most satisfactory method of removing iron and manganese from the city water. As the result of a long series of experiments, it was found that a satisfactory removal was brought about by limited areation, followed by submerged contact with coke. The coke prefilter was 8 ft. in depth and the water was applied at a rate of 67,500,000 gal. per acre per day. The effluent from the prefilter was filtered through a sand filter at a rate of 10,000,000 gal. per acre per day.

## STUDIES OF CHARACTER AND RATE OF SILTING OF ELEPHANT BUTTE RESERVOIR, U. S. RECLAMATION SERVICE.*

A study of the silt problem at Elephant Butte Reservoir was made by Messrs. R. R. Goghlan, cement chemist, and Victor E. Lieb during March and April, 1916. The investigation was undertaken with the idea of determining the weight of moisture-free sediments in a cubic foot of deposited material as found on the reservoir bottom and the probable sequence of deposition of such sediments. With these points established, the rate of accumulation of sediment in the reservoir can be approximated by study of inflow and sediment percentage records. In the following notes an attempt will be made to state briefly the methods employed and to summarize the more important data given in Mr. Coghlan's report, particularly as they bear on the general subject of silting of reservoirs.

In figuring the probable "service" of reservoirs projected on the Rio Grande, various investigators have supplied figures for the weight of a cubic foot of compacted dry sediments varying from 53 to 90.89 lb. Various estimates of the weight of a cubic foot of silt for rivers other than the Rio Grande range from 33.4 to 140 lb. The latter weight was attained on a river in India and is quoted by Parker in his treatise on "The Control of Water." As defined by Mr. Follett, in his report to the State Department on "Silt in the Rio Grande," which is a comprehensive and complete compilation of the data on stream flow and silt content of the river from 1889 to 1913, "the Rio Grande silt contains no sand coarse enough to be perceptible. It is composed of finely desiccated and almost impalpable clay and alluvium and it settles slowly."

The silt beds for sampling were so selected that the samples should be typical and as representative of average conditions as possible. The samples were taken from bars deposited in the lake during the high water of June and July, 1915, during which time an elevation of 4,321.81 ft. was attained at the head of the lake. The sampling was undertaken in March, 1916, when these bars were entirely exposed excepting along a channel in which the river was then flowing. The lake had receded to elevation 4,312.7 at this time. The bars were located in the "Box Canyon," about 15 miles upstream from the Elephant Butte dam. During the high water of 1915 the river was entering the lake at the upper end of the canyon, and the lake remained at this elevation for about two months.

Samples of the moist bank silt were obtained by clearing off the surface coating, cutting an approximate prism of the silt, removing the surrounding material, and inserting a thin piece of sheet iron or glass beneath the specimen which was then rapidly brought to shape, accurately measured, and weighed in a balance scale, reading to 0.1 gram. A sample was then taken from the interior of the specimen and placed in a hermetically sealed bottle to be used for moisture, specific gravity, and other determinations in the laboratory. Great care and diligence were used to prevent evaporation and loss of particles through the agency of sun and wind.

Another method of sampling was tried similar to that used in previous investigations by Mr. Fenz. An accurately calibrated tin cylinder was forced into the silt until flush and then removed by excavating the surrounding material. The ends were trimmed and the cylinder and its contents weighed. The weight of the cylinder being deducted, the remaining value should accurately represent the weight of that volume of silt. In sampling a compact bank, however, if the edge encountered a pebble or stick, the pressure necessary to force in the cylinder was sufficient to distort the end, and only with exceptionally clean silt or a bank completely saturated can this method be used satisfactorily.

In the laboratory, moisture was determined by quickly and accurately weighing a portion of each sample from the sealed bottle into a tared nickel crucible and drying for five hours in an electrically heated oil oven at 110° C., a temperature sufficient to remove all hygroscopic water, but insufficient to expel the chemically combined water, or to break up carbonates or organic matter. The desiccated samples were then cooled over fused calcium chloride and quickly weighed. The percentage of moisture was then calculated.

The specific gravity was obtained by taking equal amounts from each dried sample and carefully mixing them; 55 grams of this composite were then weighed out and carefully and slowly introduced into a Le Chatelier standard specific gravity bottle filled to the zero mark with distilled water. The determination was made with but little difference in temperature between the filled bottle and the sample, and each determination took an hour to prmit the escape of the large amount of air entrained by the silt. Failure to remove this air would result in an error amounting to at least 4 per cent. Fineness of the silt particles was determined by the regular method advocated by the Bureau of Standards for determining the fineness of cement.

Samples of water at different points were taken by the use of a tilting bottle, which could be filled at any desired depth; three samples being taken at each depth and combined. At first an attempt was made to determine the amount of silt by sedimentation in calibrated glass cylinders, but it was quickly apparent that this method was inaccurate and unsatisfactory because of the high percentage of collodial material which compacted with extreme slowness. This method was replaced by that of direct weighing. The sample was thoroughly shaken and

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*From an article in Reclamation Record for September, 1916.

100 cubic centimeters quickly withdrawn with a pipette and evaporated to dryness in a tarred beaker, giving the percentage by weight; this being further corrected for the amount of dissolved solids present in the water of the sample. This method is accurate and quick, and the only means of arriving at the true percentage, as it is independent of voids, specific gravity, and other factors involved in a volume determination of a comminuted solid or mixture of solids.

Samples from the silt beds were taken at three different localities, the first about 15 ft. from the river and 1 ft. above it, the second 65 ft. from the river and at a slightly higher elevation, and showing unmistakable signs of having been exposed longer, both about 1 mile above the delta, and the third at a point about 2 miles above the delta, from a bank about 20 ft. from the water and 1 ft. above. Results from 17 samples from these three locations are tabulated by Mr. Coghlan. The significant values in the detailed tabulation may be arranged as follows:

| | Maximum. | Minimum. | Average. |
|---|---|---|---|
| Weight per cubic foot natural state | 124.31 | 96.68 | 104.75 |
| Percentage moisture | 20.89 | 4.45 | 11.56 |
| Weight per cubic foot dry state | 101.18 | 87.90 | 92.34 |
| Specific gravity | 2.657 | 2.590 | 2.642 |
| Percentage of voids | 46.57 | 38.97 | 43.99 |

The fineness of grain of the samples from these locations is given in the following table:

| Sieve. | Location A. Per cent. | Location B. Per cent. | Location C. Per cent. |
|---|---|---|---|
| Passing No. 200 | 88.14 | 79.64 | 76.56 |
| Passing No. 100 | 99.78 | 99.64 | 99.29 |

An ever-present characteristic of the banks was a surface deposit of from 3 to 5 ins. of a dark red unctious mud which could be molded readily when moist, but which was quite dense and coherent in structure when dry. Below this light layer of mud is the silt proper; brownish in color when slightly moist and gray when saturated. That these deposits are of two distinct types is shown by the following partial analyses of samples of moisture-free silt and moisture-free surface covering:

| | Silt. Per cent. | Argillaceous covering. Percent. |
|---|---|---|
| Total silica, $SiO_2$ | 74.44 | 48.96 |
| Iron and $Fe_2O_3$<br>Alumina, $Al_2O_3$ | 12.78 | 27.96 |
| Calcium oxide | 3.48 | 4.20 |
| Magnesium oxide | 1.91 | 3.15 |
| Loss on ignition | 3.12 | 2.85 |

The covering is essentially argillaceous, while the silt proper is a mixture of quartz and feldspathic material and some argillaceous material, which on account of the rapidity of deposition on reaching quiet water is entrained with the other two. The remarkable uniformity in the amount of argillaceous material present is shown by the following proximate analyses of two silt samples about a mile apart:

| | Sample A. Per cent. | Sample B. Percent. |
|---|---|---|
| Argillaceous material | 16.80 | 16.62 |
| Feldspathic material | 26.40 | 30.53 |
| Quartz | 56.80 | 52.85 |
| | 100.00 | 100.00 |

Tests of the water samples taken show percentage of silt by weight varying as follows:

| | Discharge, 7,000 second-feet. Per cent. | Discharge, 4,000 second-feet. Per cent. |
|---|---|---|
| 5 miles above delta | ........... | 0.498-0.560 |
| 2 miles above delta | 1.090-1.660 | ........... |
| At delta | 1.015-1.053 | .113- .355 |
| 1 mile below delta | .030- .277 | .0032 |

The variation in percentage at each particular locality depends upon depth at which the samples were taken, the minimum amount being near the surface. In the river and delta channels the silt is carried in approximately the maximum percentage throughout the lower half of the stream section. The water samples taken at the delta show less silt by weight than those in the flowing river above, but the ratio of volume to weight is 30 per cent greater. The results shown in this table indicate that the shallow water of the delta receives nearly the entire load of silt. During the 7,000 sec.-ft. discharge in March, the delta channel carried about 5 ft. depth of water, with many shoals of hard compact silt, free from mud where near the surface. Muddy water was visible about 200 ft. out into the lake.

The tests show that as the silty water approaches the delta it becomes increasingly freer from silt and the remaining material becomes more argillaceous in character, until that which passes over the delta is almost pure clay. One mile below the delta samples were taken at intervals of 5 ft. from the surface down to 30 ft. depth. The water was only slightly turbid and nothing resembling silt was encountered until the bottle sank into a rich red ooze of pure clay. The percentage of silt shown by the composite sample of water was 0.0032 per cent by weight, an insignificant amount. This ooze is evidently the dark-red surface deposit which was mentioned above and which is deposited in a thin coating over the silt beds as the reservoir rises and the delta moves upstream. During periods when the water level in the reservoir is falling the river ordinarily has small discharge and forms a comparatively narrow channel through these beds, leaving the greater part of the surface coating as it was deposited until the reservoir again rises and the heavier delta silt is deposited upon it at the same stage that the first beds were formed. As long as this ooze remains submerged there is little possibility of consolidation. We have evidence that such material can attain a dry weight of 94 lb. per cubic foot, or more when long enough exposed to sun and air.

A statement forecasting the service life of the Elephant Butte Reservoir from the data at hand is questionable at best, but a surmise will not be amiss. The available storage capacity of the reservoir is computed at 2,638,860 acre-feet. Using the records of flow and percentage of silt which passed San Marcial, N. Mex., from 1897 to 1912, inclusive, computed by Mr. Follett, and the weight of 92.34 lb. of dry silt per cubic foot of deposit, we find the average annual inflow of silt into the reservoir area during that period was 11,336 acre-feet. Based on this figure, the probable life of the reservoir may be computed as approximately 233 years. This may be influenced by variable and unknown conditions. It might be predicted that with the reservoir silted to half of its capacity and with the delta toe approaching the dam, a succession of dry years in the river above the reservoir would not mean a cessation of water from the reservoir, as the 44 per cent, more or less, of voids in the silt would insure a steady supply of seepage water which would add materially to the flow.

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## PERSONALS.

A. O. Wolff has been appointed Resident Engineer of the Canadian Pacific Ry. with headquarters at Chapleau, Ont.

Ross Miller has been appointed engineer of the South Dakota Railroad Commission, succeeding J. E. Lone, resigned.

F. B. Tapley has been appointed Assistant Engineer of the Canadian Government Rys. with headquarters at Moncton, N. B.

D. K. Caldwell has been appointed engineer of Caddo Parish, Louisiana, to succeed J. T. Bullen, whose resignation is mentioned elsewhere in this column.

Thomas L. Goldie, formerly Assistant City Engineer of Regina, Sask., died Aug. 28 at Manchester, England, from infective Jaundice, acquired while serving as gunner in the 16th Battery, C. F. A.

Lieut. Col H. N Ruttan, formerly city engineer of Winnipeg, Man., and later consulting engineer for the city, has been promoted to Brigadier General. Mr. Ruttan for some time has been District Officer commanding at Winnipeg.

Frank M. Veatch has been appointed Superintendent of the water purification plant of the American Water Works & Electric Co. at East St. Louis, Ill. Mr. Veatch severs his connection as Assistant Engineer of the Kansas State Board of Health on Oct. 1.

J. T. Bullen, formerly Senior Engineer of the U. S. Office of Public Roads, and later Parish Engineer of Caddo Parish, Louisiana, has resigned to become highway engineer of road districts in Raleigh County, West Virginia, which are planning the expenditure of $850,000.

Applications will be received until Sept. 21 by R. C. Campbell, City Clerk of Sault Ste Marie, Ont., for a manager, qualified, with commercial and executive experience, to manage municipal water works and electric light system. Civil engineer with electrical experience is preferred in view of alterations contemplated to water works system.

Arthur H. Halloran (vice-president and managing editor, Journal of Electricity, Power and Gas) has been appointed Pacific Coast representative of The Society for Electrical Development. Mr. Halloran's headquarters will be in the Crossley Building, San Francisco, Cal. Mr. Halloran will represent the Society in the states of California, Arizona, Nevada, Utah, Idaho, Oregon and Washington.

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## INDUSTRIAL NOTES.

The general offices of the O. F. Jordan Co., manufacturers of Jordan Spreaders and railway specialties, have removed from 332 S. Michigan Ave., Chicago, to Chicago and Kennedy Aves., East Chicago, Ind.

The Brennan Engineering Co., 36 W. Randolph St., Chicago, announces that on Aug. 1, 1916, the business was incorporated under the name of Brennan, Wahl Co. The company will act as consulting engineers, mechanical, structural, chemical and manufacturers' sales and purchasing agents for machinery and allied products.

Excavation and Railways Issue
of
# Engineering and Contracting
Halbert P. Gillette, *President and Editor*

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## WHY DO NOT ALL ENGINEERING COLLEGES DEVELOP READING HABITS?

The implication in this question is that at least some engineering colleges fail to develop in their students habits of systematic reading. What is the evidence that many engineers cease systematic study after they graduate?

Perhaps the most striking single fact is the almost complete emptiness of the reading rooms of engineering societies. The editor was for many years a resident of New York City. Upon his first visit to the library of the American Society of Civil Engineers he was impressed by the fact that he found less than a baker's dozen of co-users of the books and files of that large and excellent library. He has never ceased to be impressed by the fact that in a city containing thousands of civil engineers so few use that library often. Glance over the register of those who attend the library and you will note the recurrence again and again of the same names. This emphasizes still more the fact that the vast majority of resident members of this society rarely used its books and periodicals.

The same condition exists as to the consolidated library of the national societies of mechanical, electrical and mining engineering. And, so far as our observation has extended, it holds true also of the libraries of local engineering societies and clubs.

To one seeking explanation for this seeming anomaly it appears likely that public technical libraries are little used because engineers have their own private libraries, which suffice for all ordinary needs. But an examination of the private "libraries" of many engineers speedily shatters any such explanation. Such "libraries" are, for the most part, not worthy the name. The few books ordinarily seen on the shelves of an engineer's "library" are not only inadequate in title and scope, but most of them are not up-to-date. The same may be said of the libraries of nearly all the railway and public utility companies, where no excuse as to lack of funds will hold.

We turn next to the possibility that engineers have, in general, found it better to subscribe for engineering periodicals than to buy many books. Technical books, it is often said, are usually out of date before they are off the press. While this is not true, let us assume that, like many another false but popular generalization, it is regarded as true. If so, and if engineers are usually studious after graduation, we should find very large circulations for every good engineering periodical. The publisher of one of the largest engineering papers recently told the editor that he had a mailing list of 100,000 prospective subscribers and an actual subscription list of 20,000. This accords closely with the editor's personal knowledge of the field.

In our issue of Aug. 30 we gave statistics from the last U. S. census indicating that there are today approximately 150,000 civil engineers, surveyors, civil engineering draftsment and contractors for civil engineering work. This does not include superintendents and foremen who are not civil engineers. The combined circulation of Engineering and Contracting and the two other large civil engineering weeklies is approximately 50,000. Hence, for every present subscriber for these papers there are at least three and probably more men who should subscribe!

Again, consider the significance of the fact that none of the four great national engineering societies has a membership much exceeding 8,000. Consider the civil engineers of your own acquaintance who are not members of the American Society of Civil Engineers. Making every possible allowance for the fact that many engineers feel that they cannot afford to pay the dues in such a society, it still remains almost a mystery that the membership is relatively so small.

We say it is "almost a mystery." The mystery, we think, vanishes when we realize that engineers are more like other men than engineers have been willing to concede. They are not, as a rule, sufficiently studious of their problems. And this brings us face to face with the question that forms the title of this article.

There is, we fear, something radically wrong somewhere with the methods of mental training that are applied in many if not most of our engineering colleges. For, above all things, the habit of systematically seeking for and utilizing scientific data should be so deeply formed in engineering students that it will persist through life.

Prof. Harold V. Bozell, director School of Electrical Engineering of the University of Oklahoma, recently wrote to the editor of Electrical World outlining a course of study of engineering periodicals that has been in effect three years in his school. He says:

> The course mentioned is an attempt to take care of the weaknesses or deficiencies in training of the engineering college and to bridge the gap. in a way, between the text and the work. All magazines and proceedings of societies as they are delivered at the university, pass over the desk of the head of the department of electrical engineering. who uses characteristic marks on the different articles, indicating whether the article is to be read and discussed, or whether it is to be merely called to the attention of the student.
>
> All students are required to give thorough study to all of the periodicals in a given list, and once a week, for a period of at least two hours, the instructional force of the department meets all the seniors in a general or detailed discussion of the matter which has appeared during the past week.
>
> The main benefits which have been noted from this course are a development of the viewpoint of the student, an intimate acquaintance of the student with the engineering periodicals, an added interest in the relation of engineering to the economic world in general, and an added grasp of the value and the opportunity of the engineer in present-day affairs.
>
> Since the inauguration of this course, which has now been running successfully for three years, all of the graduating classes are unanimous in their verdict as to the benefit of the work—they view its value as being perhaps greater, for the time spent, than that of any other course in the curriculum.

We have quoted this interesting experiment to indicate one of several means that may be adopted to develop habits of study that will persist in after life. But if this or any other similar plan is adopted, why confine it to senior students? Habits may be started but are rarely formed in a year. Four years is none too long a time to create any habit. The first-year students should begin to search systematically for usable information. They should be impressed with the fact that it will not suffice to know how to reason. An engineer must also know where to find the best and most complete data with which to reason. To accomplish this end he should never cease systematic, thorough studying as long as he practices engineering.

## PRESIDENT WILSON'S NARROW CONCEPTION OF ECONOMICS.

If public policies were determined entirely—as they doubtless are partially—by the opinions of editors, there would soon be enacted a law compelling railway employees to submit all their grievances and claims to judicial decision, such, for example, as the Interstate Commerce

Commission would render. But the country is at least directly ruled by professional politicians and not by the editors of the daily press. So, in spite of the most general editorial condemnation of the act, Congress and the president surrendered to the demands of the railway labor unions; and, under the guise of enacting an eight-hour day law, railway trainmen have secured a 25 per cent increase in wages.

In our issue of June 28, we stated that, aside from the tariff, the most important political issue before the American people was the question of federal control not only of railway rates, but of railway wages and conditions of labor. We pointed out that none of the party platforms showed adequate recognition of this fact. Yet, when President Wilson was recently confronted by the demands of the labor unions, he acted and spoke as if an unexpected crisis had come upon the public unforeseen by anyone. The crisis had been foreseen for years by every student of public rate making and public regulation of railways and other utilities.

This is not the first time that the president has ignored the warnings and advise of experts. Indeed, he apparently has a natural antipathy toward "expert advice," and a self-sufficiency in foresight and judgment that often amounts to pure egotism. In the present instance this lack of respect for the opinions of experts on public regulation brought him suddenly at face with the gravest of problems, and with almost equal suddenness he came to a decision that was fundamentally wrong. Never was his lack of economic experience more evident. Never was he a greater slave to a generalization of inordinate breadth.

When Woodrow Wilson was president of Princeton University an article from his pen appeared in Scribner's Magazine, November, 1909, entitled "What Is a College For?" Even then his scant regard for and still more meager conception of engineering was evident; so much so that we took exception to his statements in an editorial published in our issue of November 10, 1909. Not only because that editorial serves to illuminate President Wilson's greatest weakness—a lack of scientific and economic training—but because the views on education, as expressed in that editorial, need reiteration from time to time, we reprint the editorial in full in this issue.

## "WHAT IS A COLLEGE FOR?"

Woodrow Wilson.

### Our Answer.

(Reprinted from Engineering and Contracting, Nov. 10, 1909.)

In the November Scribner's Magazine the president of Princeton University, Mr. Woodrow Wilson, offers an answer to the question above displayed. The answer that he offers is not the less interesting because it lacks novelty, for novelty is hardly possible in any educational subject. Particular interest to the graduate of an engineering college will be found in the following utterance of Mr. Wilson:

> There should be technical schools, a great many, and the technical schools of America should be among the best in the world. The men they train are indispensable. The modern world needs more tools than managers, more workmen than master workmen. But even the technical schools must have some thought of mastery and adaptability in their processes; and the colleges, which are not technical schools, should think of that chiefly. We must distinguish what the college is for, without disparaging any other school, of any other kind. It is for the training of men who are to rise above the ranks.

It is clear from this quotation (the last sentence of which we have emphasized), as well as from other parts of his discussion, that Mr. Wilson does not recognize any such thing as an "engineering college." There is, in his conception of the word college, only one class of college, whose scope is fairly well indicated by his citation of "philosophy," "some one of the great sciences," "some one of the great languages which carry the thought of the world," "history," and "politics," as being the principal things in which a college man should be grounded.

In brief, he throws all engineering colleges into the class which he denominates "technical schools." When this is appreciated, there is certainly small flattery to engineers in the conclusions that they will draw from his words above quoted.

Mr. Wilson regards the "technical schools" as factories that produce "tools," whereas the "college" is a place to train the "master craftsmen," who will wield these human tools.

We agree wholly with Mr. Wilson's conclusion that a college is a place for training men to be leaders, but we submit that, having prescribed this test of what a college should be, there is but one way to determine what a college really is, and that is to find whether its graduates have attained positions "above the ranks." By this test, every good engineering "school" is entitled to the name of college. For what one among them has not graduated scores of men who are leaders in the industrial world? The list of alumni of any established college of mechanical engineering brings surprise after surprise when names familiar in the manufacturing world are found.

In the mining world the surprises are only less frequent because the number of graduates from mining colleges is fewer; but when one comes upon such names as Augustus Heinze, the copper king, who received his training at the School of Mines, Columbia University, there is certainly abundant reason for pausing to ask where a more astounding "rise above the ranks" can be found among the graduates of the old-fashioned college, or "school of arts," such as Mr. Wilson favors. This is not one of those rare "exceptions that prove the rule," for it is worthy of the strictest note that the majority of the graduates of the established mining colleges have risen to positions of authority, often of great authority.

In the railway field, it is natural to expect to find civil engineers in large numbers holding "officers' commissions." The number is not so large as it should be, and when a civil engineer, like Cassatt, the late president of the Pennsylvania Railway, passes away, we feel regret not only at his death, but at the uncertainty whether his successor will be an engineer also.

Thousands of graduates of civil engineering colleges are contractors—builders of railways, dams, canals, roads, skyscrapers and the hundred and one other structures designed by civil engineers. This is scarcely being mere "tools" in the hands of "master workmen."

Notwithstanding much that the engineering colleges lack in the way of a training that would best fit their students to become leaders of men, we believe they come far closer to Mr. Wilson's ideal of what a college should be than he himself has ever dreamed. In common with most men whose education has been in the arts rather than in the sciences, he clings to the belief that a training in philosophy, language, history and politics constitutes the modern scolastic quadrivium essential to the average man who would rise above the ranks. Was it as long as fifty years ago that Herbert Spencer (a civil engineer who became the greatest of all philosophic teachers) put the first pin into the bladder upon which such arguments float? Without referring to Spencer's essay on education, our recollection is that its opening sentence reads thus:

"Men dress their minds, as they do their bodies, in the prevailing fashion."

Then followed his now classic arraignment of the then existing methods of education in which science played no important roll, while language, history and the arts had all the title parts. That same antequated system of education is the one Mr. Wilson seeks to maintain, with the addition of "one of the great sciences." Thus slowly change the fashions of the intellectual dress of men! Still, they change.

But let us not be too critical of those who hold to the old styles—the wearers of the velvet waistcoat, the stock, the gay "small clothes" and the silver buckles, albeit they have recently taken to the spiked shoes of science that they may run the faster. Our own engineering buildings may have steel frames and concrete floors, but the windows are of glass. The same ideas that control Mr. Wilson's judgment are to be found in similar, though modified, control of many of the educators at the heads of our engineering colleges. **There is an almost prehis-**

toric belief among educators that there must be some one "broad" course of study that will best fit a man to enter any subsequently selected vocation and win renown.

Even in our vocational colleges—our engineering colleges—there has always been the most strenuous opposition to specialization. It is scarcely 20 years ago that the editor of a prominent engineering journal undertook to prove that a special course in mining engineering was objectionable in the highest degree. He argued that one broad course in civil engineering would better serve to educate the future mining engineer than a narrow course in mining engineering. To those who had at that time graduated as mining engineers this charge of narrowness was indeed laughable; and the subsequent steady increase in the popularity of courses in mining engineering, coupled with the remarkable achievements of the graduates from mining colleges, has amply vindicated the laugh of twenty years ago. Thus, in fact, does every new vocational course eventually find its vindication.

Only a few years ago, engineers were tempted to smile when they first heard the term "agricultural engineering"—an engineering farmer, indeed! A precious lot of science does the average farmer need! Where is the smile now? Our agricultural schools—true schools of a lower grade at first—are rapidly evolving into agricultural colleges, institutions whose training, we venture to believe, will prove to be as educative and broadening as that to be had today in our great colleges of engineering. And if we are to apply to them the test above prescribed—the rise of their graduates above the ranks—we shall find them abundantly able to qualify as colleges.

The trouble has been with most of our educators that they have failed to perceive the true distinction between knowledge and mental training. They have looked at the medals upon the breast of the athlete rather than upon the hardened muscles that won them. Yet, they all loudly protest that they, too, are believers in training; but in the next breath they insist that only such and such a mental diet will give the desired mental strength. Pardon us if we descend to colloquialistic exclamation and say—Bosh!

We have known athletes who trained, after the old English style, upon a diet of ale and red rare meats; and we have known others who have abstained from alcoholic beverage and have trained entirely upon vegetables. Yet when the race was run, the contest was one of neck to neck excitement, the victory going to the man with the greatest stamina—natural, plus acquired—wholly regardless of the particular kind of food he had eaten.

The first great essential of any educational diet is that it shall not pall upon the appetite of the individual. He must go to his every meal with a hearty gusto. Herein lies the real secret of the success of those who have pursued vocational studies. The young man who enters upon a course in chemical engineering usually does so because his ambition is to become, let us say, a large manufacturer of fine pottery. The young man in the civil engineering course has, let us say, conceived the idea that he can thus reach the presidency of some great railway. The young student of architecture hopes to become the designer of noble buildings. The young mining engineer feels that some day he may control, if, indeed, he may not own, another Anaconda. When young men, fired with ambitions such as these, take their places in our technical colleges, it is not for the mere fun of it, not for the whiling away of four years in sports and romance. They are there to work, and that, Mr. Wilson, is precisely what you bewail as being the lacking element in the average man who pursues the old-fashioned college course—the course in arts leading to an A. B.

Now, it matters little how a man works his muscles, whether it be with chest weights or with dumbbells; for, so long as he works them regularly and diligently, strength is bound to develop. So will strength of brain come to the student if he works, regardless of what mental dumbbells or cerebral chest weights he uses. But he must work.

Men really work only when driven by the "blacksnake" of ambition. When thus scourged, their efforts are often prodigious, and in this manner do the feeble take on strength, while the strong become mighty. Ambition, however, is never roused by vagueness of purpose. There must be a goal in sight, or at least picturable in the camera of the mind. This is usually possible only to the young man who is pursuing vocational studies.

Going a step farther, we see that the more specialized the vocation that is taught, the greater the certainty that the students will work with increased energy, and consequently with more assurance of developing large mental strength. Instead of opposing the demand for new courses, our colleges should encourage the development of as many courses as their funds will permit. Are there young men who aim to become contractors? Then give them not a broad course in civil engineering, but a broad course in contracting engineering, or engineering contracting. Are there young men who aim to be second Edisons? Then refer them not to a broad course in electrical engineers, but provide a broad course designed to stimulate the inventive faculty.

Yes, these specialized courses can be made broad, in spite of the seeming contradiction in terms. They can thoroughly ground the young man in the science of mathematics, which is the basis of all science, and that in itself is tantamount to giving no slight breadth of attainment to any man.

They can impart the power to express one's thoughts in clear and vigorous language, and that, too, is an evidence of breadth of mind.

They can carry logic into every study, as well as make a study of logic itself, and that is a still greater criterion of mental breadth.

They can develop a knowledge of philosophy, which, if we accept Spencer's definition, is but the unification of science under the all-embracing laws of evolution, which itself is a corollary of the persistence of force.

They can require a student to master a foreign tongue, not for what ancient knowledge is stored therein, but for what present science it contains.

They can add to all these a thorough mastery of the particular vocational studies for which the student has come to college. This power to master any vocation is itself broadening beyond ordinary belief.

Finally, through all the course thus given, should be taught that systematic recording and reporting of work performed that characterizes the modern American factory. The college itself, by being run after the fashion of a factory—and not in the hit or miss, individualistic style characteristic of the present—can thus become an object lesson in management, during every day of the four years that the student lives within its walls. Is a student engaged in making a chemical analysis? Then his daily report should embody a time "log" of his actions as well as a record of results. Is he making a survey? Then every element of time involved should be recorded, so as to teach him how an analysis of recorded time elements leads to a reduction in the minutes required for a given process.

We shall not now discuss the various methods of developing system, rapidity of performance, precision, and the other essentials to managerial success; but these can be acquired largely from coming under the proper college management itself, supplemented by some one or more text-books on the subject of management. In brief, the management of men by modern methods of systematic reports, time studies, and analysis of the data thus obtained, is well within the province of every college, although it is now characteristic of few.

Not by reading history, nor politics, nor philosophy, nor foreign language, can this science and art of managing men be acquired, as Mr. Wilson apparently believes. Still less does it come from gazing at the "milky way" in the heavens of knowledge or by telescopic viewing of "sample" stars.

A college, as Mr. Wilson conceives it, and as we conceive it, is a place for training men to rise above the ranks. This training, however, has the greatest effect only when the student is actuated by a definite and inspiring motive, and the motive can ordinarily be supplied only by the desire to become pre-eminent, or at least prominent, in some definite vocation. Vagueness of purpose as to the vocation is fatal to the ambition of the student. Hence the more specialized the vocational study, the greater is the certainty that it will be pursued with pertinacity, which pertinacity itself is the mark of all mental strength, and has, indeed, been designated as the sole characteristic of genius.

Thus we have the paradox of developing breadth of the brain by narrowing the field of study. Yet, when all is said, what study, or group of studies, can be more than narrow when laid upon the measure of human achievement? Is Latin broad? Is history? Is politics? Is "one science"? Heaven forbid that many men regard them so! Latin is a splendid study, perhaps unexcelled as a preparation for one who would master the English tongue. But, as for ourselves, it has long seemed that a four years' course of Latin in a good high school serves every purpose.

History is like the maps that Lewis and Clark made when they crossed the continent to Oregon, an inspiring record of man's achievement, but most of it so ancient as to be useless as a chart by which to pilot any present or future course for the caravan of state.

Politics? Political economy for the average man is also a study for the high school and for the leisure hours of post-graduate life. It rarely helps a man to earn his livelihood, inspires few students, has no substance upon which the learner's teeth may chew. Yet, withal, it is an embryonic science that some day may become food for men. At present it is worse than bob-veal.

"One science"? Yes—one and some more, and all aimed to lead the student to a mastery of the vocation he has chosen.

Thus, with aims identical, we advocate means widely at variance. Mr. Wilson, in common with several other distinguished presidents of universities, is fighting against the inevitable multiplication of vocational studies. He admits their necessity—for those who would be "tools"—but he fails utterly to see that it is these very vocational courses that are training the master minds of the coming generation.

Like the Germanic hordes that overran southern Europe in the fifth century, because they sought more lands to conquer, the graduates of our engineering colleges are overflowing the boundaries of their profession—though in no barbarian fashion—and forcing their way into managerial control of the great industries of America. We predict that civil engineers will shortly be heard of in politics—even now they are silently entering that field—and then we may hope for the combined honesty and intelligence of administration so sadly lacking now in our municipal governments. What, indeed, is municipal government's greatest concern today, if it is not the economic building and maintaining of civil engineering structures, such as water works, sewers, pavements, coupled with the regulation of public service corporations (also of an engineering nature), such as street railways, gas and electric plants? What class of men is best fitted to rescue municipalities from misrule?

One needs but to ask the question to see the hand of logic upraised and pointing at the graduates of the engineering colleges of America.

## STEAM SHOVEL EXCAVATION IN SHALLOW CUTS.

Contributed by Tirrell J. Ferrenz, Assistant Engineer, Chicago Surface Lines.

The Chicago Surface Lines build on the average from 50 to 60 miles of single track per year. Inasmuch as the city of Chicago embraces over 200 square miles of territory within its corporate limits, widely divergent soil conditions are encountered in this work. These include a large amount of stiff clay and sandy soil, together with considerable swamp land and in some instances of outcropping rock. It is the practice, wherever conditions permit, to employ a steam or electric shovel in excavating to subgrade for the track structure.

The standard type of construction, as approved by the Board of Supervising Engineers, provides for depths of 21⅜ in. and 23⅜ in. from the street grade to track foundation, the width of cut commonly being 18 ft. 2 in. for double track.

The following results were obtained by a detail time-study of excavation on West 51st St., between Leavitt St. and Central Park Av., a distance of 1¾ miles:

| | |
|---|---|
| Depth of cut, average | 26 in. |
| Width of trench | 18 ft. 2 in. |
| Kind of material | Stiff clay |
| Type of shovel | Thew steam shovel |
| Capacity of shovel | ⅝ cu. yd. |

**Swell of Broken Ground.**—The quantity of material in place was obtained by taking levels at various points and computing the yardage for each 10-ft. section. Loose earth was removed by wagons which were loaded full each trip.

| | |
|---|---|
| Lineal feet excavated on test | 230 |
| Total place measurement, cu. yd | 230 |
| Number of loads | 221 |
| Capacity per load, cu. yd | 2 |
| Total loose material, cu. yd | 442 |
| Swell of broken ground, per cent | 34 |
| Time Excavating and Loading: | |
| Wagon in position for loading, min | 0.25 |
| Time for loading, min | 1.52 |
| Getting under way, min | 0.20 |
| Moving up shovel, min | 0.20 |
| Minimum time per load, min | 2.17 |
| Average time per load, including all stops, delays, etc., min | 2.52 |
| Average number of loads per 10-hr. day | 238 |
| Cubic yards loose material loaded per 10-hr. day | 476 |
| Cubic yards in place loaded per 10-hr. day | 355 |
| Lineal feet excavated per 10-hr. day | 243 |
| Cubic yards in place per lineal foot | 1.46 |

**Time Hauling.**—Hauling was done by a teaming contractor under a general agreement covering the removal of all excavated material within the limits of a specified territory. Hauling by wagon over common, fairly dry, unpaved streets required 0.50 minute per 100 ft.

Thew Shovel Excavating for Chicago Surface Lines.

| | |
|---|---|
| Rate per 100 ft., incl. stops, lost time, etc., min | 1.085 |
| Average length of haul, ft | 800 |
| Hauling time per trip, min | 17.36 |
| Total time per trip, incl. loading, min | 19.88 |
| Number trips per team per 10-hr. day | 30 |
| Number teams required | 8 |
| Labor Excavating and Loading: | |
| 1 engineman at 75 ct. per hour | $ 0.75 |
| 1 fireman at 34 ct. per hour | 0.34 |
| 10 laborers at 22½ ct. per hour | 2.25 |
| Per hour | $ 3.34 |
| Total per 10-hr. day | 33.40 |

The gang of ten laborers was used in moving shovel platform, furnishing coal and water for shovel, dressing up ditch and loading wagons. One shovel watchman was employed at $2.50 per day. His duties consisted in watching shovel and keeping up fire at night. A lunch period of 30 minutes was allowed at noon.

| | |
|---|---|
| Cost of Supplies for Shovel: | |
| 3 tons Pocahontas coal at $5.25 | $15.75 |
| 5 gal. cylinder oil at $0.40 | 2.00 |
| 3½ gal. engine oil at $0.275 | 0.96 |
| 3 lb. colored waste at $0.07 | 0.21 |
| 1½ lb. white waste at $0.105 | 0.16 |
| 2 lbs. cup grease at $0.08 | 0.16 |
| Total cost per week of six days | $19.24 |
| Cost per day | 3.21 |

Summary of Costs:

| | Per 10-hr. day. | Per cu. yd. loose mtl. | Per cu. yd. in place. | Per lin. foot. |
|---|---|---|---|---|
| Excavating and loading | $33.40 | $0.070 | $0.094 | $0.137 |
| Watching shovel | 2.50 | 0.005 | 0.007 | 0.010 |
| Supplies for shovel | 3.21 | 0.007 | 0.009 | 0.013 |
| Total | $39.11 | $0.082 | $0.110 | $0.160 |

## SOME DREDGING COSTS BASED ON ACTUAL DREDGING EXPERIENCE.*

Dredging costs vary in different districts according to conditions encountered and the methods of calculation employed, and even in the same district and under the same management dredges of similar size and design or the same dredge in different parts of the same property will show a wide difference in operating cost owing to the character of the ground dug.

**Dredging in United States.**—The largest dredging company in the world, the Natomas Consolidated, of California, operated 13 dredges in 1914 and handled 25,850,000 cu. yd. at a total cost of 5.8 ct. per yard. To show the wide differences in dredging costs of dredges operating under the same management the following is given: One dredge for the year above mentioned handled nearly 2,000,000 yd., at a cost of 2.5 ct., and another dredge handled over 2,000,000 yd., at a cost of 7.14 ct., differences in the depth and the character of gravel causing the difference in cost. The power cost of the first dredge was 0.6 ct. per yard and that of the second 1.32 ct., with other cost details also differing greatly.

The ten dredges of the Yuba Consolidated at Marysville, Cal., handled a total of 17,000,000 yd. at a cost of 4.40 ct., varying from 3.29 to 6.86 ct. a yard, according to the dredge and conditions of operation and repairs. The dredge charged with the higher cost underwent reconstruction which was charged to the yearly operations of 1914.

In Montana, as described in Mr. Jennings' paper, the cost of handling a total yardage to July 31, 1915—more than 32,000,000 yd. was 59.1 ct. a cubic yard with indirect expenses of 1.05 ct., the total cost was 6.96 ct. a yard. Operating costs for different dredges for the total period mentioned varied, according to the size and type of dredge and to the operating conditions, from 4.85 to 6.94 ct. a cubic yard.

In Colorado, the dredges of one company handled, in 1914, 3,000,000 yd. at a cost of 5.9 ct. a yard. One of the dredges in Idaho handled 4,670,000 yd. for the same year at a total of 2.77 ct. The yardage mentioned is the record for any single dredge in the world. Other dredges operating in the United States obtain costs according to conditions of operations, size of boat, etc., varying from 5 to 10 ct. a yard.

**Dredging in South America.**—In South America, the Pato dredge in Colombia for the year ended Sept. 30, 1914, handled 920,000 cu. yd., at an operating cost of 18.4 ct., which, with general and office expenses, brought the total expenditures to 23.2 ct. per cubic yard. For the year ended Sept. 30, 1915, the operating cost was estimated at 16 ct. a yard and the yardage handled was considerably in excess of that for the previous year, 1,420,000 cu. yd. being handled. This dredge is equipped with 8-ft. buckets, and the operating conditions were not considered as being unfavorable for a tropical country when the dredge was built.

**Dredging in the Philippine Islands.**—Dredging costs in the Philippine Islands have been greatly under those mentioned above. The work of the Gumaos dredge is given in detail in Mineral Resources of the Philippine Islands. This is a 5-ft. dredge and has handled during 27 months of operation, from Oct. 1, 1912, to Dec. 21, 1914, a total of 1,850,000 cu. yd., at a cost of about 12 ct. per cubic yard.

**Dredging in Alaska.**—To go from the Tropics to the far north is rather a radical change, but the operating costs in the far north are in excess of those in the Tropics on account of shorter seasons, frozen ground, and various other operating and economic difficulties.

The costs of the various dredges of the Yukon Gold Co. for the year 1913 varied from 21.16 to 33.79 ct. yer yard, the highest cost for thawing being given as 18.36 ct. Approximately 75 per cent of the gravel is frozen.

Dredging costs in Alaska may be said to vary from 20 to 30 ct. a yard, though in some instances a much lower operating cost is claimed. However, in all instances coming under the writer's observation, the actual cost has not been less than the first figure given.

**Dredging at the Panama Canal.**—A paper on placer-mining costs at this time would seem incomplete without some reference being made to the work at the Panama Canal.

According to W. G. Comber, in a paper on dredging in the Panama Canal, presented at a meeting of the International Engineers' Congress, San Francisco, September, 1915, the grand total quantity of material removed from the Panama Canal and auxiliary works by dredging from 1905 to December, 1914, was 115,700,000 cu. yd. The total cost per cubic yard was 26.77 ct., including the work of ladder, dipper, and suction dredges and the total cost of operation, maintenance, material, plant, and administration.

Considerable interest has been shown by gold-dredging operators in the performance of the large bucket ladder dredge equipped with two lines of buckets, one having a capacity of 1 cu. yd. and the other of 2 cu. yd. The bucket lines are interchangeable, one being used for heavy digging and the other where the work was lighter. The total material handled by this dredge from April, 1912, to January, 1915, is given at 3,351,600 cu. yd., and the cost at 36.59 ct. per yard.

In excavating the canal the material from bucket, dipper and sea-going suction dredges was delivered to barges and hauled 4 to 10 miles to a permanent dump. The intermittent nature of the work and the long haul account in a measure for the high operating cost. Although comparisons between the work of these dredges and those operating in different placer fields is, of course, futile, most gold-dredge operators will have a feeling of satisfaction when they consider these figures in connection with the operating costs of their own machines.

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*From Bulletin 121, Bureau of Mines, by Charles James and Henry Jennings.

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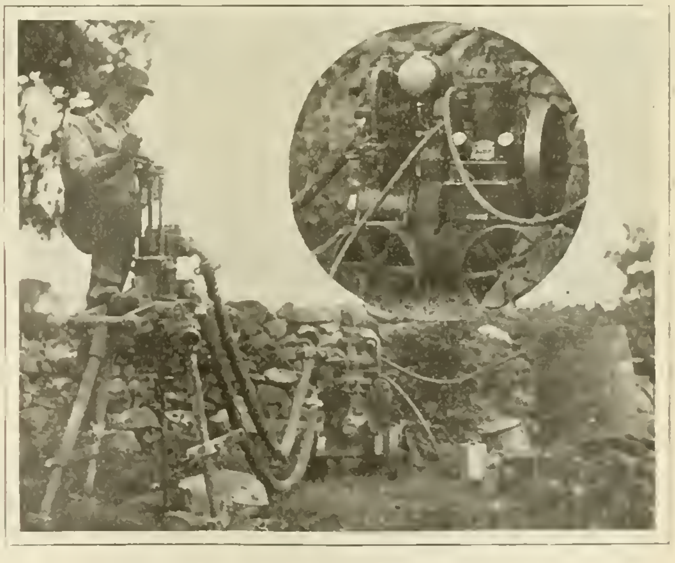
## ROCK DRILLING WITH A GASOLINE-AIR DRILL.

Contributed by H. L. Hicks, 11 Broadway, New York.

The Kenn-Well Contracting Co., who are constructing an 18-mile electric transmission line for the New York Edison Co., has in use a new type of gasoline operated rock drill. This they employ for drilling large diameter holes for the anchor bolts which will secure the latticed steel towers.



Gasoline-Air Drilling Outfit.

The novel drilling outfit is the gasoline-air type, of Ingersoll-Rand manufacture. As the hypen indicates it is a combination rather than a single unit. The actuating force is produced by a 6-h. p. two-cycle gasoline motor which, through gearing drives a pulsator. The latter is in effect a double-acting air pump connected by two lengths of hose to either end of the drill cylinder. This connection is direct—without valves or obstructions. The drill is of the reciprocating piston type with rifle bar rotation, but without the complication of valves and valve passages and ports.

The drill is reciprocated by air played back and forth a closed circuit by the pulsator. This action is similar to that of the well known electric-air drill. The gasoline engine operates at 780 R. P. M. and is geared to operate the pulsator at 440 R. P. M. or, in other words, reciprocate the drill at a speed of 440 blows per minute.

The engine is rated to consume approximately two quarts of gasoline per hour and one pint of oil mixed with each five gallons of gasoline. The barrel, which will be noticed in the illustrations, is the convenient reservoir for the thermo-siphon cooling system. Ignition is of the jump spark type, dry cells and spark coil in the engine base furnishing the current.

The outfit is handled for transportation as two units, the pulsator-engine truck and the drill with its mounting. The heaviest piece, the pulsator unit, weighs about 600 pounds. The relatively light weight is of great advantage in moving the outfit over the broken country in Westchester Co., N. Y., where the work is being done.

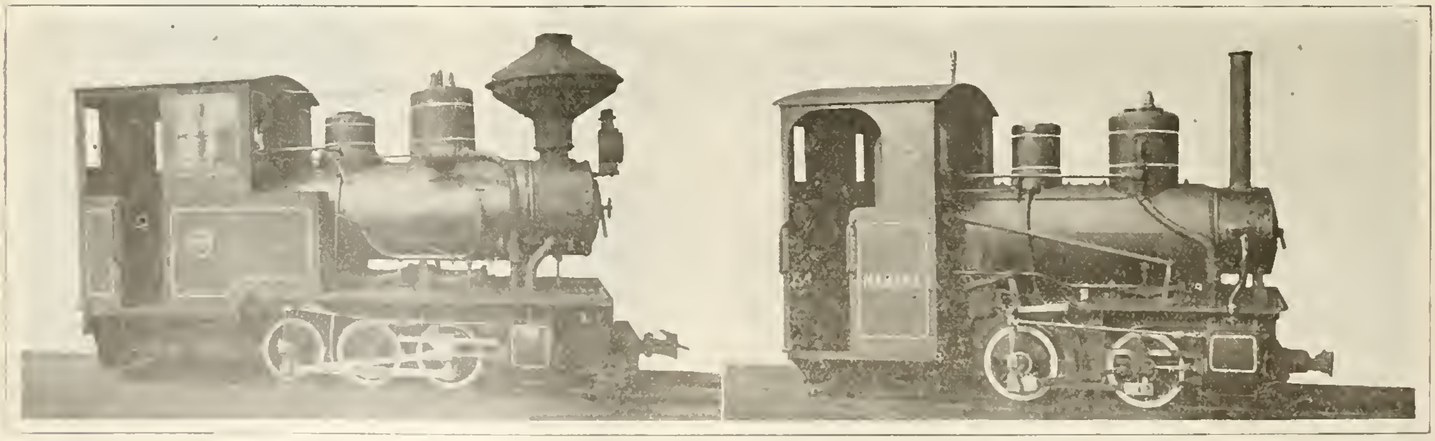
The anchor bolt holes which are required average 5 ft. in depth. They are started with a 3-in. bit and bottom at 2¾ in., an unusually small gauge variation. The necessity of drilling a vertical hole in the very seamy rock encountered has made it inadvisable to attempt speed in cutting the rock. A total of twenty feet of drill hole in a set of four holes has been observed on different occasions to require three, four, five hours and sometimes even longer, depending on the character of the rock. In drilling in concrete, eight 4-ft. holes 3 in. in diameter were completed in four hours, including time required to change the set-up of the drill.

This type of drill appears to be fully equal in capacity and drilling speed to the standard air or steam tripod drill of equal size. Its independence of compressor or boiler power supply and its compact portability should recommend it on many jobs where a single heavy-duty machine is required for drilling scattered holes.

## THE BALDWIN LOCOMOTIVE WORKS—DECAUVILLE TYPE LOCOMOTIVES FOR LIGHT SERVICE.

(Contributed)

The selection of a locomotive for light industrial or contractor's service, is a matter to which considerable attention and study should be given, as it is important that the engine be fitted for the work. These locomotives are usually of narrow gage, and must be designed to operate on uneven tracks and sharp curves. They must be strongly built, and at the same time be simple in construction, with easily accessible working parts. Ample stability is necessary, in order that the tendency to overturn, when passing over rough track and around sharp curves, may be reduced to a minimum. This usually requires a low center of gravity, especially if the track gage is very narrow.



Light Locomotives for Contractors' Service.

The Baldwin Locomotive Works have recently built a number of locomotives of the Decauville type, which meet the conditions outlined above. These engines have been constructed for export, and two of them are herewith illustrated. They have steel plate frames, and the water tank is placed between them. This construction braces the frames transversely and also lowers the center of gravity. In a locomotive with saddle or side tanks, the weight of the latter, especially when filled, raises the center of gravity; so that it is sometimes preferable, when the gage is narrow to use a separate tender. This difficulty is not encountered in the Decauville design.

The four coupled locomotive illustrated was built for the Playstowe Central Mills Co., Ltd., Australia. It is of two ft. gage, and operates on grades of 3 per cent and curves of 198 ft. radius. The track is laid with rails weighing 14 lb. per yard. The boiler is 25 in. in diameter, and carries a steam pressure of 176 lb. per square inch. It has a steel outside shell, a copper firebox, and brass tubes. Bituminous coal is used for fuel, and a coal box of 8 cu. ft. capacity is placed in the cab. The tank capacity is 102 gal.

The steam dome is placed well forward on the boiler, and the live steam pipe passes out through the right hand side of the dome. This pipe branches under the smokebox with one branch leading to each cylinder. The throttle valve is placed in the steam pipe. The cylinders are 6x10 in., and are fitted with plain slide valves. A simple design of Marshall valve gear is applied, with the parts outside the frames and wheels where they are easily accessible. The wheels are 22 in. in diameter. The equipment includes a hand brake, with shoes on the rear driving-wheels only. The cab is of steel, and is entered at the sides. The locomotive weighs 12,000 lb. in working order.

The six-coupled locomotive was built for the International Engineering and Trading Co. of Russia. The gage in this case is 2 ft. 5.53 in., and the locomotive weighs 22,850 lb. in working order. The cylinders are 8x12 in., and the driving-wheels have a diameter of 23 in. The boiler, including the inside firebox, is built of steel plate throughout. Wood is used for fuel, and in order to avoid spark throwing a smoke stack of the Radley and Hunter type has been applied. The top and bottom sections of the stack casing are each made of pressed steel in one piece. The sparks are given a rotary motion in the casing, and are broken up and extinguished before they are discharged. A fuel space of 32 cu. ft. is provided in the cab, and the water tank is of 200 gal. capacity.

Like the four-coupled locomotive previously described, this engine has plain slide valves and Marshall valve gear. The equipment includes a combined hand and Baldwin steam brake, with shoes on all the wheels.

These locomotives are neat in appearance, and are well fitted for the work they have to do. With suitable modifications in equipment, this design could readily be adapted to service in the United States.

## REMARKS ON PUBLIC SERVICE AND PREPAREDNESS FOR ENGINEERS.*

The engineer above all others will be called upon in the solution of big public problems and in the development of governmental administration, as he has been in the solution of military and industrial problems. In the military service, the engineer is called upon to reconnoiter and develop offensive and defensive engineering plans for the fighting forces and fighting machinery. Upon the engineer corps, the duty of arranging for the sanitation of the camp and for comfort and health of the military organization is placed. The engineer has been called upon to lead in the solution of problems of transportation.

No greater tribute could have been paid to the engineering profession than the recent request by the President of the United States for a citizen trained corps to prepare an inventory of the country's manufacturing and industrial resources as the first step in industrial preparedness. The engineers of this country were prepared. The patriotic and democratic pledge to undertake and complete this task is now being carried out through a committee, representing the five national engineering societies—Chemical, Civil, Electrical, Mechanical and Mining —which have a membership of over 30,000 engineers. It is such preparedness for service to the country that offers the best insurance for responsive and effective results in public administration.

To engineers credit must be given for the great achievements in connection with the construction of railways and waterways, the construction and operation of our municipal and other public works, the extension of public improvements and in the development of economic and scientific methods in the conduct of the routine of public administration. The role, which the engineer has played in the administration of affairs of our governmental bodies, has been mostly that of close application to details of administration, the importance of which have not always been brought out or fully appreciated by the public. In spite of these handicaps and the restrictions ofttimes brought about by politics and the uninformed and misinformed officials, the engineer has brought into the civil service the spirit of workmanship and ideals of scientific management and has been the first to use and instill in the minds of others the necessity of management based on scientific method.

In making any statements of achievements already accomplished through the patriotic and unselfish services of engineers, I was not unmindful of the greater opportunities which are before engineers and other trained personnel in the further development of responsible and effective public administration. Engineers, because of their analytical training, their ability to obtain and stick to facts and to act with precision, their imagination and vision for new and big things and their genuine interest and spirit of public service, have in the public service almost a virgin field.

The entry into the public service of men and women of ability and sincerity of purpose, with high ideals and nonrecognition of the negative things in the public service, will have the effect of bringing about positive and fundamental improvements in the administration of public affairs and will give further impetus to the increasing favorable attitude of the public toward governmental administration. Politics, incompetency, irresponsible and mediocre service and administration can find no comfort and cannot long survive where such conditions exist.

The total receipts and government cash payments for the nation, states, counties and cities and incorporated places having a population of 2,500 and over thus amounted to over $2,960,000,000.

Owing to lack of sufficient data on the divisions and organization of the services in these governmental divisions, it is not possible to set out definitely the exact number of positions in these services. Estimates have been made and these vary from 1,400,000 to 1,500,000 positions in these services, in addition to the 480,000 positions in the federal service, making a total of between 1,880,000 and 1,980,000 positions in the public service in this country. At the rate of increase of governmental activities, it is not improbable that before long the total number of agents required to administer the public affairs of our nation, states, counties and cities will exceed the 2,000,000 figure.

It would not be possible within the confines of this paper, to go into detail on the diversity and complexity of the problems confronting our municipalities, nor of their growing importance. A mention of some of the more important technical divisions indictes the field and broad opportunities and urgency for a trained personnel in the municipal service:

1. Finance administration and municipal accounting.
2. Taxation, budget making and municipal financing.
3. Municipal reports, publicity and statistics.
4. Technique of constructive investigation and reporting.
5. Civil service administration and standardization of employment.
6. Standardization and centralization of purchasing and testing.
7. Management and administrative procedure—scientific management.
8. Education administration.
9. Public health administration.
10. Justice, charity and correction administration.
11. Social surveys—Housing.
12. City planning.
13. Police and fire administration.
14. Public works administration and local improvements.
15. Water supply administration.
16. Municipal lighting.
17. Pavement construction and repair.
18. Cleaning of streets and removal of snow.
19. Sewerage systems and sewerage disposal.
20. Collection and disposal of city wastes.
21. Parks and play-grounds and recreation administration.
22. Elimination of smoke nuisances.
23. Regulation of local public utility rates and services.
24. Street railways, elevated roads and subways.

Within the last two years over 80 of the municipalities in this country have adopted the city manager form and there seems to be no sign of abatement in this direction. These commission-manager cities are scattered through 28 states. Michigan, which has 9 city manager cities, is in the lead. California and Texas each have 8, and Virginia and Ohio each have 7 city manager municipalities. According to geographical divisions, the North Atlantic states have 8 city manager cities; the South Atlantic states 18; North Central states, 28; the South Central states 21, and the Western states 10.

Honorable Henry Waite, city manager of Dayton, which, by the way, is the largest city that has adopted the city manager plan of government, outlines the advantages of the city manager form of municipal government as follows:

(1) Simplicity.
(2) Basis of Organization—Efficiency and Economy.
(3) Centralized authority.
(4) Fixed definite responsibility.
(5) Business methods.
(6) Prompt and effective action.
(7) Employment of experts when needed.
(8) Commissioners represent the whole city, not ward.
(9) Interests a higher type of man in city service.
(10) The short, non-partisan ballot.
(11) Abolishes politics from the administration end of government.
(12) Separates the legislation from the administration.
(13) Does not depend on ballot to select trained men for particular functions of government.

These problems of public service which are presented by the new order of things, are being recognized by a growing proportion of our people. This is shown by the new civic spirit which has arisen in our municipalities and the attitude of the increasing number to serve as watchful and informed citizens, or as agents to carry out the affairs of government in a way such as to raise the horizon of civic and community service.

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*Excerpts from an address by J. L. Jacobs to the Western Society of Engineers.

The field of public service, which is performed by these citizen agencies has increased with the growth of the functions of government. Opportunities are not only offered for work in these organizations, but governmental officials have turned to them for men and women to fill official positions requiring training and experience of public administrative problems and the knowledge of the structure and operations of government. Increasing activities and co-operation of these civic agencies with governmental bodies is bound to create a further demand for trained workers in public administration. The more important organizations and associations, which have been developed and are active in this positive and growing field, are the following:

Ballot associations.
Boards of trade.
Bureaus of municipal research.
Chambers of commerce.
City clubs.
Civil service reform associations.
Commercial clubs.
Educational associations.
Foundations for special research.
Health associations.
Housing reform associations.
Industrial associations.
Juvenile associations.
Legal aid associations.
Legislative leagues.
Local improvement associations.
Merchants' associations.
Municipal leagues.
Real estate associations.
Recreation associations.
Tax associations.
Training schools for public service.

Opportunities in the civil service are increasing faster than the supply of men and women who are trained and interested in the public service. Steps must be taken for thorough and sustained practical preparation for public service administration. The creation of a larger supply of men and women, who are trained and are genuinely interested in public affairs and wish to find a career in the official life, will go very far towards stimulating further demand for experts. This, I believe, will largely solve our problem of efficient and responsible public administration. There have been a number of suggestions and programs set out for developing such a trained army of civil servants. In the adoption of the following steps, there lay the solution for preparedness and increased opportunities in our public service:

1. Publicity of public administration and of researches on government and public administration.

2. Extension of merit system and positive employment methods and control.

3. Practical training for public service in connection with our educational programs and with civil service administration.

4. Federal enactment for the promotion of public service training and distribution of federal appropriations amongst individual states and cities on uniform basis.

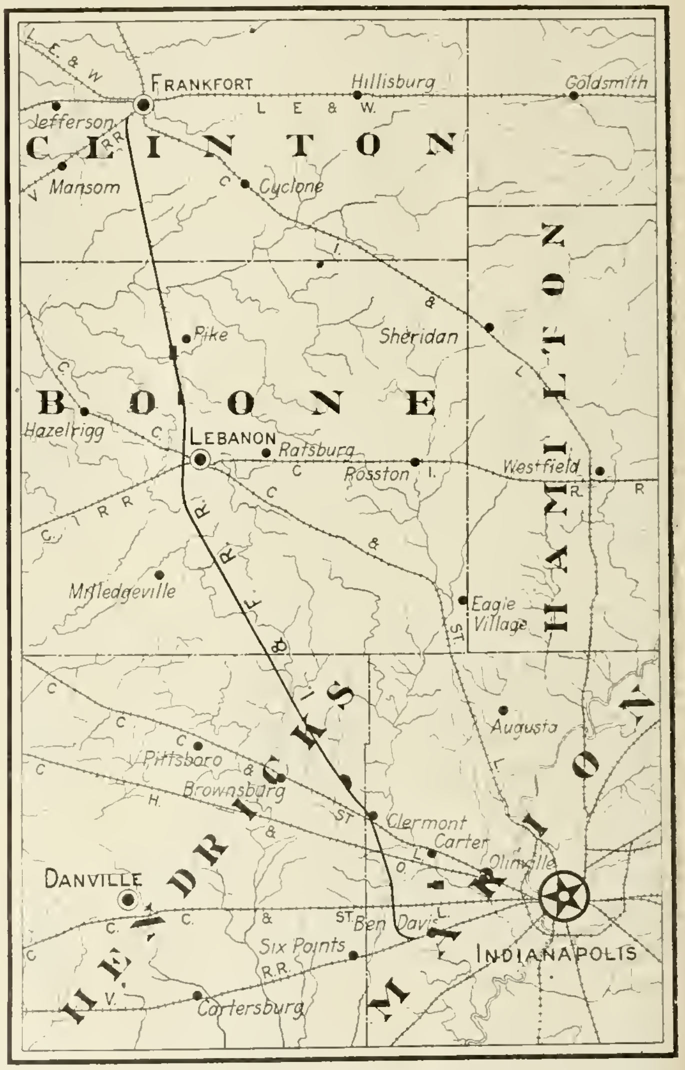
5. Co-operation between administrative departments of the federal government, states and cities and our state and other educational institutions, providing for practical training and field work in public service.

6. Encouragement of training of public service to teachers and compulsory instruction of principles of democracy and public administration to children and immigrants.

7. Recognition of public service as a profession of dignity, social prestige and permanence.

## THE NEW 41-MILE LINE IN INDIANA FOR THE PENNSYLVANIA R. R.

Excavation is just getting well underway on one of the largest new line railroad construction jobs undertaken in the middle west so far this year. This work calls for the building of the Indianapolis & Frankfort R. R., a 41-mile road extending from Ben Davis, Ind., to Frankfort, Ind. This line is being constructed for the Pennsylvania R. R. It meets the St. Louis Division of the Vandalia about 6 miles west of Indianapolis and runs in a generally northwestwardly direction, connecting with the Michigan Division of the Vandalia at Frankfort. The route is shown on accompanying map. The line will have a single track roadbed with bridges and right-of-way for double track. The grading involves approximately 3,000,000 cu. yd. of earth, most of which will be taken from borrow pits purchased along the line. The first 6 miles is on an average fill of about 27 ft. due to the fact that it is necessary to cross several steam railroads and traction lines on overhead crossings. The remainder of the grading is light except through the city of Lebanon where it is necessary to elevate the tracks on account of steam and electric lines. There will be no railroad crossings at grade



New Pennsylvania Line From Ben Davis to Frankfort, Ind.

All bridges will be of the latest type of reinforced concrete construction, except at four railroad crossings where it will be necessary to use steel trusses in order to span the entire right-of-way. There will be approximately 60,000 cu. yd. of reinforced concrete construction requiring 1,700 tons of reinforcing steel.

The Dunn & McCarthy Co., 405 South Dearborn St., Chicago, Ill., has the contract for building the entire line, under the supervision of Mr. F. T. Hatch, St. Louis, Mo., Chief Engineer of the Vandalia R. R. L. H. Robbins, 124 Fair Bldg., Indianapolis, Ind., is in charge of the work for the contractors.

## COMPARISON OF TWO METHODS OF SHAFT SINKING THROUGH SOFT MATERIAL.

In shaft sinking for coal mines, the cost item greatly influences the method adopted. This holds true especially when soft material must be traversed. The average life of a coal mine is short. This is due either to the limited area of the coal basin or to the great expense of maintenance and haulage underground when the entries are extended a considerable distance from the hoisting shaft. Therefore, the engineer in opening a coal mine is confronted with the fact that the cost must be kept within certain bounds else the venture will prove unprofitable. For this reason he may be prohibited from adopting certain safe, but expensive, methods that are used in sinking caissons for foundations, driving transportation tunnels, or other work of permanent construction.

A common method of sinking through difficult ground employs the aid of a steel shoe pushed ahead of the shaft timbers. Another is the drop-shaft method. These two methods were used in sinking the main shaft and the air shaft of the Eagle No. 3 mine, at Des Moines, Ia., and the following data show the relative success and cost of the two methods of sinking under the same conditions.

A drill log of the material to be penetrated was as follows (see Fig. 1):

| | Thickness, Ft. | In. | Total Depth, Ft. | In. |
|---|---|---|---|---|
| **Drift** | 38 | | 38 | |
| Sand | 2 | | 40 | |
| Drift | 2 | 6 | 42 | 6 |
| Jointed clay | 5 | 6 | 48 | |
| Drift, firm | 10 | 6 | 58 | 6 |
| Clay, with sand streaks | 3 | | 61 | 6 |
| Sand | 12 | | 73 | 6 |
| Shale, with two thin beds of coal and thin strata of rock | 86 | 6 | 160 | |
| Rock | 5 | | 165 | |
| Coal | 3 | 9 | 168 | 9 |

### Main Shaft Sunk by Steel-Shoe Method.

This record shows the first 73 ft. to be drift material, the lower 12 or 15 ft. of which was sand. The remaining 92 ft. to the coal was shale and rock, and offered no trouble in sinking.

The general equipment, purchased from a company that had twice attempted to sink on this property and failed, consisted of one 80-hp. boiler, a hoisting engine, one No. 5 horizontal and one No. 6 vertical Cameron pump, a dump car, hoisting buckets, etc. The men employed were a day and a night engineer, one timberman, and three sinking crews, each consisting of three sinkers and one top man. Work was continuous 24 hours a day until the sand was reached, when it was cut to two shifts, the remaining time being used in repacking pumps, etc.

The excavation was made 8 to 14 ft. The curbing for the first 50 ft. consisted of 2 by 4 and 2 by 6 timber laid flatwise, alternately with a quarter shaft bratticed off with 3 by 12 material, and the hoisting compartments divided by 4 by 6 buntons.

No trouble was experienced in sinking until the bed of sand at the 38-ft. level was encountered. This sand carried a small amount of water and, as a shaft protection, a concrete ring was put in behind the curb. The next trouble was experienced from the 42 to 48-ft. level. It had been the intention to assemble the shoe at this level, but what appeared to be a firm green clay proved to be jointed clay with a seam of quicksand through it and the exposed wall would not stand. Temporary 2 by 12 curbing was put in place and then regular curbing carried on down.

At the 50-ft. level, in order to safeguard the assembling of the steel shoe, 125 wooden mine ties, 3 by 4 in. by 4 ft. long, were sledged into the clay just below the curb as shown in Fig. 2. Steel angles, 6 by 4 in., were fastened with lag screws to the under side of the ties. An excavation 6 ft. deep was then made, undercutting the ties 16 in., and a false curb of 2 by 6 boards built. The shoe was then assembled at this point.

The shoe consisted of four sheets of ⅜-in. steel, two 8 ft. long by 5 ft. high and two 14 ft. long by 5 ft. high, with 3-in. angles at the corners, and a 6-in. pressure angle placed 18 in. from the bottom of the shoe. The curbing was then built inside the shoe to a height permitting the jack screws to be placed against the curb timbers of the shaft, as shown in Fig. 2.

The clay was then excavated, the shoe lowered into the sand, and pumping started. The sand carried about 60 gal. of water per minute, which would rise about 18 ft. above the sand when pumping was stopped.

In order to avoid the formation of cavities behind the curb, as little sand as possible was excavated. To prevent an inrush of sand under the shoe, at least 1½ to 2 ft. of sand had to be left within the shoe. The method of sinking was to agitate the sand at the bottom of the shoe and force the shoe through it by means of the jack screws bearing against the shoe and the curb of the shaft. Two methods were used to agitate the sand. First, while the men could reach the bottom of the shoe, they stirred the sand with spades. By this method the shoe was lowered about 18 in. in the sand. Later the pumping system shown in Fig. 2 was used.

In this second process the discharge of the No. 6 pump could, when desired, be sent through five ¾-in. pipes, as indicated in the drawing, and these five jets of water could be played upon the sand at the bottom of the shoe. It was found that these jets would agitate the sand sufficiently to permit the jack screws to push the shoe down, except when the sand was at too high a level inside the shoe, in which case sand would have to be excavated before the jet process could be resumed. In using this process the men would stir the sand with the jets for about 10 min., and then tighten the jack screws. When sufficient space was obtained between the timbers in the shoe and the curbing above, the jack screws of one side were removed, and sets of timber put in place on top of the timbers in the shoe, and then the other jack screws were moved. An advance of 18 in. per day was exceptional by this method. More often it was less than a foot.

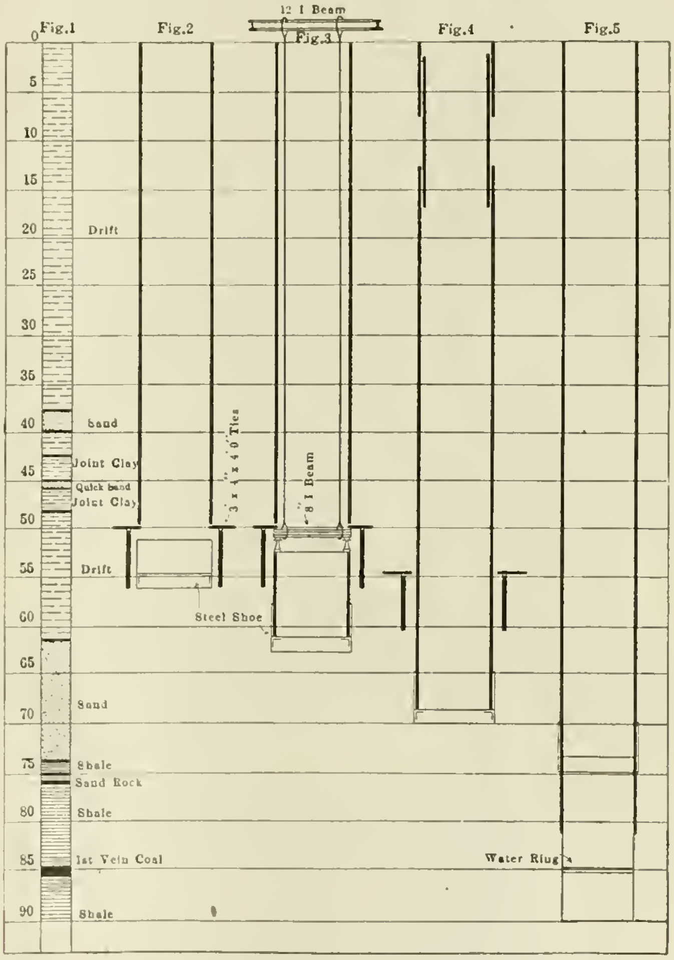


Fig. 1—Diagram of Material Penetrated and Progress in Sinking Shafts

Necessarily some sand had to be excavated at times. This had a tendency to cave the dirt around the shaft, which in turn caused an excessive down pressure and broke the curbing apart a number of times. An attempt was made to overcome this trouble by supporting the curb with I-beams and cables from the surface as shown in Fig. 1, Fig. 3. Ten 12-in. I-beams were supported on cribs at the surface, and ten 8-in. I-beams were swung under the 4 by 6 angle below the ties, these beams being connected by twenty ⅞-in. steel cables. When the sinking was resumed, the curbing continued to break, the I-beams bent, and two cables were broken. Since it appeared impossible to hold the curb, it was decided to timber the shaft solid from the 8-ft. level (where the most uniform break occurred) to the bottom of the shoe, and then drop this portion of the shaft through the remaining 5 ft. of sand.

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*From a paper by E. A. Sayre in Transactions American Institute of Mining Engineers for September, 1916.

To do this, the ties were driven back into the wall and solid timbering put in between the shoe and the upper curbing of the shaft. The entire shaft curbing from the 8-ft. level down was then tied together with 2 by 6-in. stringers. At the 8-ft. level, 2 by 4-in. by 16-ft. planks were spiked to the lower curb, the upper ends projecting above the break as shown in Fig. 1, Fig. 4, preventing the loose material from falling down the shaft. The jet system, with occasional excavations of sand, was resumed, and the shoe, with 50 ft. of curbing, was lowered through the sand.

In landing the shaft on the solid, seven boulders from 1 to 2 ft. in diameter were encountered. Six of these were under the cutting edge of the shoe, and were removed only after being broken up by means of a long chisel and sledge.

While lowering the shaft through the sand, the upper timbers of the shaft buckled 18 in. out of line. This necessitated retimbering of the shaft from the top of the sand to the surface, an expensive undertaking because the old timbers had to be cut out and replaced in sections.

On completion of the retimbering, sinking through the shale was commenced. Three shifts of four sinkers each were used with an average daily advance of 5 ft. The only problem involved in sinking through the shale was the elimination of the water, a considerable proportion of which was choked off when the solid was reached. This water was taken care of by placing a water ring at the 85-ft. level with a pump located at that point to elevate the water to the surface as shown in Fig. 1 and Fig. 5.

### Air Shaft Sunk by Drop-Shaft Method.

The air shaft was located 350 ft. from the main shaft, and its sinking conditions were similar except that the surface at this point was 10 ft. lower than at the main shaft, making the actual distance to be traversed to the solid 63 ft. 6 in.

The equipment was the same as that used at the main shaft. The air shaft followed a drill hole tapped by an entry from the main shaft, so that most of the water was drained through this drill hole and then pumped to the surface. Two shifts of three sinkers, one top man, and an engineer were employed.

The size of the excavation was the same as before, 8 by 14 ft. The steel shoe was similar to the one in the main shaft, except that it was 10 ft. high instead of 5 ft. The timbering for the first 30 ft. above the shoe consisted of 4 by 6 laid flat, tied together by lag screws ⅝ in. diameter by 10 in. long, spaced 2 ft. apart. The shaft was divided into three equal compartments by 4 by 6 buntons as shown in Plate 3. The middle compartment was left free and was used for hoisting purposes. The end compartments were braced by 4 by 6 extending from the ends of the shaft to the sides. Four steel straps ⅜ in. by 2 in. tied the shaft timbers together from top to bottom.

An excavation 10 ft. deep was first made, the shoe assembled and lined with timbers. The sinking was continued until the shoe was hung up by the friction on the sides. Then a platform was built every 5 ft. in the end compartments. These 5-ft. chambers were filled with sand to give additional weight, and the sinking continued. The ground surrounding the shoe gradually broke in an oval shape. At one place it was necessary to fire a small charge of powder in order to loosen the ground sufficiently at one end of the shaft.

As the shoe was sunk, timbers were added at the top of the curbing. This method of building the curb at the top is decidedly better than that of adding timbers at the bottom since the timbers are placed much more accurately and expeditiously.

One difficulty experienced in the drop-shaft method was to keep the bottom of the shoe level. When one side of the shoe got lower than the other it kicked the opposite side outward. To right it, the lower side was blocked until the higher side caught up.

The progress through the drift material, until the sand was reached, was slow, much slower than at the main shaft. The drop-shaft went much faster, however, after reaching the sand. In fact, the difficulty at that time was to keep the bottom of the shaft from moving faster than the top. When within 10 in. of the bottom of the sand, the shaft broke apart 20 ft. up from the shoe. This was due to the fact that the movement of the shoe was faster than that of the top of the shaft, and to the insufficient strength of the straps connecting the top and bottom of the curb. At this point (20 ft. above the shoe) the curb separated from 6 to 8 in., and the upper part of the shaft kicked over 9 in. north and east of the lower part. A temporary platform of 8 by 8 timber was put in the end compartments of the shaft at this place, and time given for the upper part of the shaft to settle down before starting the excavation again. The sinking was then continued and the shoe landed on the solid without further difficulty, aside from hitting two small boulders at the bottom of the sand.

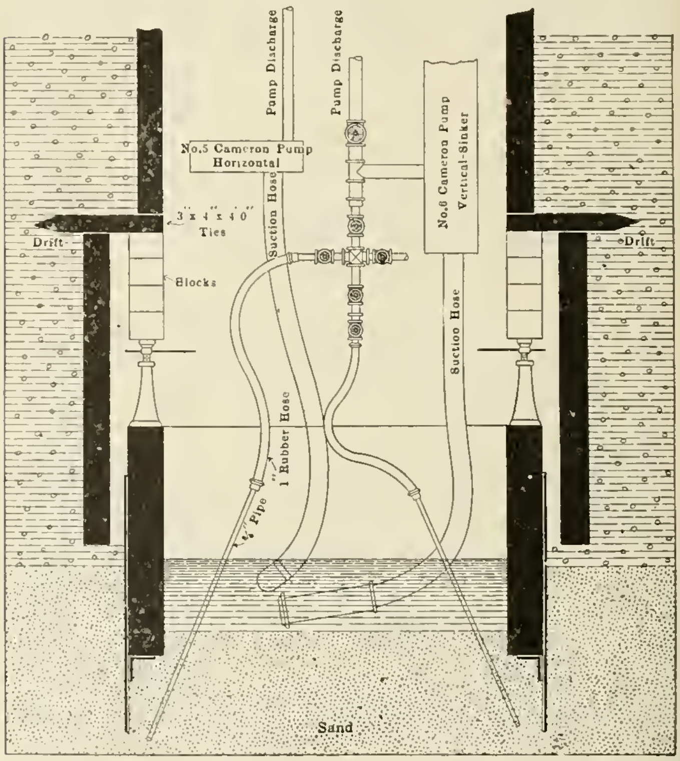


Fig. 2—Detailed Sketch of Sinking Shoe, Jack Screws and Pumps.

As the excavation was larger than necessary for an air shaft, it was decided to cement the shaft for a distance of 28 ft. from the bottom of the shoe, in order to shut off the water. A wall of cement 4 to 8 in. thick was accordingly then constructed.

After the cement was given time to set thoroughly, the excavation was again started in the shale and continued without difficulty to the coal. Sinking through the shale in the air shaft cost slightly more than in the main shaft because work in the mine prevented as careful supervision being given the sinkers in the air shaft.

One difficulty encountered in drop-shaft sinking was in keeping the position of the shaft vertical. At one time this shaft was 2 ft. out of plumb. By regulating the movement at the bottom of the shoe, the shaft partly righted itself, until at the finish, in a total depth of 63 ft. 6 in.

to the shale, the bottom of the shaft was 16 in. to the south and 10 in. to the east of the top. Part of this variation was remedied in the cementing of the shaft.

A much larger amount of sand was removed in sinking the air shaft by the drop-shaft method than in sinking the main shaft. This could be done without danger of a cavity forming, because the surface dirt followed the air shaft down as it descended. When the sinking through the sand was completed, the surface directly surrounding the air shaft had caved to a depth of 15 to 16 ft. and for a distance of 20 ft. in all directions from the shaft. In fact, all the shale that was removed through the remaining 92 ft. to the coal did not fill this space at the surface.

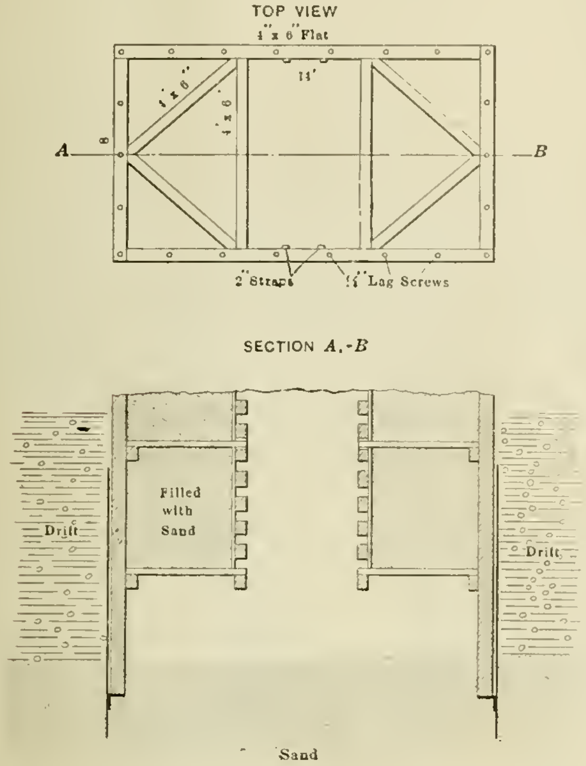


Fig. 3—Method Employed in Sinking Air Shaft.

A comparison of the costs of the two shafts is as follows:

| | Main shaft. | | Air shaft. | |
|---|---|---|---|---|
| Labor: | | | | |
| Through drift material | $ 916.80 | | $ 879.08 | |
| Through sand | 1,941.80 | | 541.62 | |
| Through shale | 1,065.68 | | 1.213.30 | |
| | $3.924.28 | | $2,544.00 | |
| Superintendence | 600.00 | | 435.50 | |
| Retimbering | 1,343.23 | | ...... | |
| Cementing | ...... | | 207.68 | |
| Total labor cost | | $5,867.51 | | $3,187.18 |
| Materials: | | | | |
| Curbing | $1,878.62 | | $1,195.17 | |
| Supplies | 900.14 | | 642.74 | |
| Power, light, water, insurance, etc. | 1,218.50 | | 649.71 | |
| Total curbing, etc., cost | | $4,027.26 | | $2,487.62 |
| Total costs of shafts | | $9,894.77 | | $5,674.80 |

## Conclusions.

In this particular work there was no question about the superiority of the drop-shaft method of sinking. It made a net saving of $4,300 in the total cost of the air shaft compared with the main shaft. A saving of $2,700 was effected in the labor cost, while in the cost of materials, power, etc., the saving was $1,600. A saving in time also resulted, 30 days being required to traverse the sand with the main shaft, while the air shaft was dropped through it in 17 days.

From the results obtained in these two shafts, and from the experience of others in the western interior coal field, we believe that the drop-shaft method of sinking is the safest, most economical, and most successful that can be adopted for sinking through soft material that lies within 100 ft. of the surface. At greater depths a variation of the method can be used by first sinking a larger shaft close to the soft material, and then telescoping a drop-shaft within it.

## PROCEDURES THAT REDUCED COSTS IN SINKING FOUR INCLINED MINE SHAFTS.

The four articles on shaft sinking methods which follow exhibit well the variations in methods that slight differences in conditions impose. Each example also records some procedure varying from the normal and found economical. In the first article attention is called to the carriage of the mucking bucket on a ropeway attached to the hanging wall of the shaft. The second article describes a method of carrying the bucket on skids on the footwall. Article three is notable for the means adapted to clear the flatly inclined shaft from smoke after blasting. The fourth article analyzes the time costs and progress in shaft work done at unusual speed. These articles are contributed by Albert E. Hull, Sable River, Copper Co., Massey, Ontario:

### I.

### Method of Sinking an Inclined Shaft, Cream Hill Mine, Ontario.

The completed shaft at this mine was 8x24 ft., but the shaft that was sunk, as we understand shaft sinking, was only 8x12 fit., or half the size of the finished shaft. This first half having been completed, the second half was stoped down into it. The shaft was inclined at 68 degrees. Two bars were used, with one machine on each bar. It was found that 22 holes were required to give a good break of the ground. A double cut was used, but only four holes were drilled for the inside cut, while six were put in for the outside or second cut holes. The sketch, Fig. 1, shows the shaft in plain and both longitudinal and cross section. The four inside cut holes are marked 1 and the outside cut holes 2. For the rest of the round or "square up" six holes on each side of the shaft were found necessary and sufficient. This makes a total of 11 holes on each side of the shaft, or 22 holes in all. In blasting, the inside cut holes marked 1 were fired first and the second set of cut holes marked 2 were fired next. After the shaft had been mucked out the rest of the holes were fired. The cuts usually pulled about 7 or 8 ft., using about 450 to 500 sticks of powder to the round. Gelignite, a Canadian Explosive Co. product, was used. The important part in any rock excavation is to get the cut out. If this is gotten out clean the rest of the round comes easily. Therefore in the case in question if a cut did not come very well when blasted the first time it was always blasted again before any attempt to blast the remainder of the round was made. This shaft was sunk in schist and the cost of this first part ran from about $22 to $25 per ft.

Mucking was done into a bucket pulled to the level above by an air hoist located on the level. The bucket worked in the end compartment of the shaft and the skip which ran to the surface was lowered in the next compartment, so that the bucket could dump into it. The hoist used had two drums. One of these carried the hoisting rope attached to the bucket, while on the second drum was the rope for the bucket trolley to travel on. The machine men before pulling their machines down upon completing a round always drilled a hole near the bottom of the shaft, as shown, into which an eye bolt was inserted, and one end of the running cable was attached to this. The cable needs to be very tight and it was usually made so by turning the steam on and pulling it as tight as possible and then setting the brakes. This made a very satisfactory mucking arrangement.

After the first half of the shaft had been completed work was started on the second half. This part was simply stoped down into the first half. The blast threw the muck to the bottom of the first half. The number of holes used in the second part depended on the ground to be taken out and varied from 8 to 12. The cost of this half of the shaft was low, as the work approaches that of stoping. It ran about $12 per foot. No drilling time was lost when working in the second half due to mucking. As soon as all the holes had been drilled and blasted and the bench—because the second half of the shaft was really a bench—had been scaled and cleaned

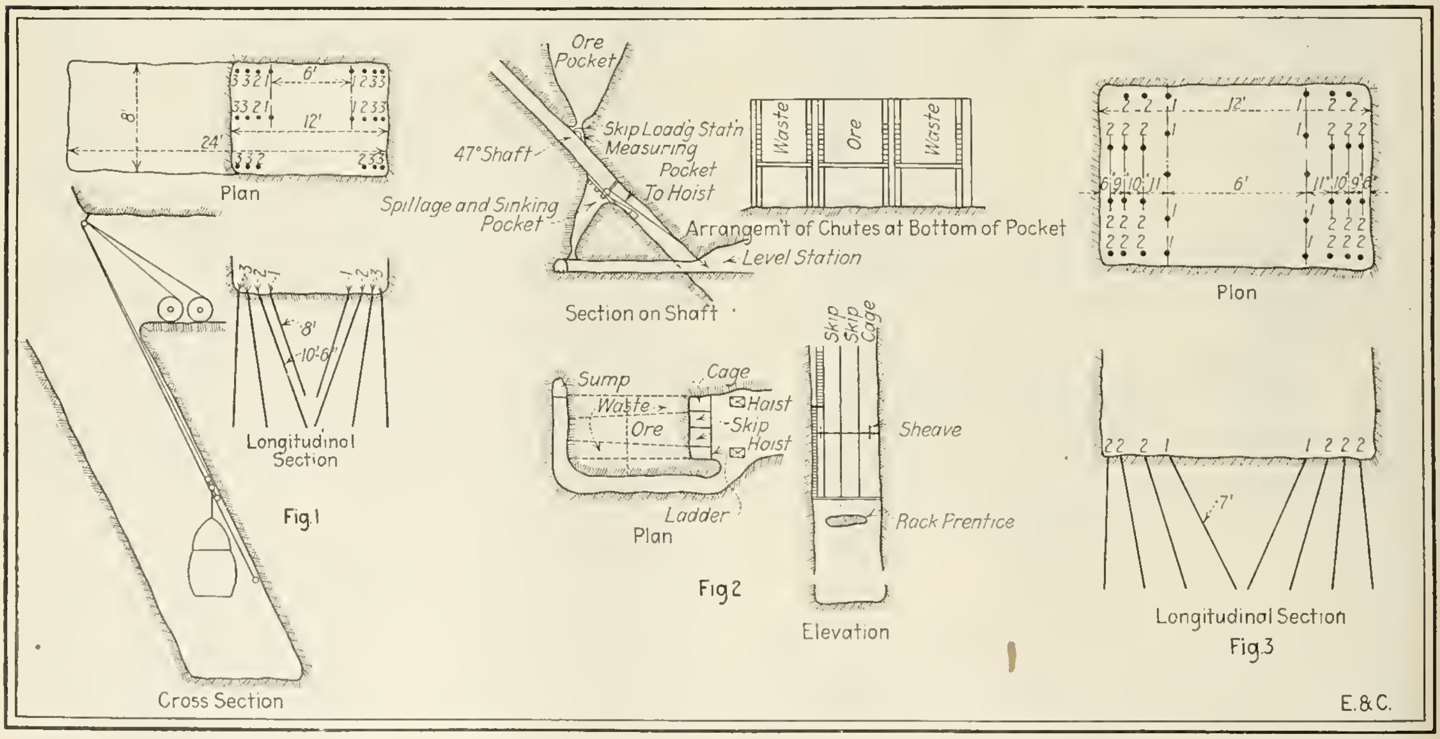
TABLE 1.—SUMMARY OF SINKING RECORD, NO. 3

| Year 1916. | Advance. | | | Total time for sinking operations. | | | | | | | Work. | | Drilling. | | | Labor in Shifts | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month. | From depth. | To depth. | Month's advance. | Drilling. | Blasting. | Blowing smoke. | Mucking. | Timbering. | Setting up. | Delays. | Number of skips. | Calc. develop., tonnage hoisted. | Rounds pulled. | 8-hr. machine shifts. | Total feet drilled. | Drill runners. | Drill helpers. | Muckers. | Surface trammers. |
| August .... | 206 | 332 | 126 | 28.3%<br>210-37 | 13.1%<br>97-17 | 2.7%<br>20-20 | 47.2%<br>350-51 | 3.5%<br>26-29 | 4.5%<br>33-11 | 0.7%<br>5-15 | 3,022 | 3,590 | 18 | *123.2 =<br>308.3 | 2,668 | 513.6 | 519.0 | 987.8 | 359 |
| September | 332 | 478 | 146 | 28.2%<br>203-01 | 7.8%<br>56-10 | 5.8%<br>42-08 | 50.0%<br>359-48 | 2.3%<br>16-23 | 5.0%<br>36-11 | 0.9%<br>6-19 | 3,026 | 4,161 | 21 | 294.0 | 7,291 | 476.4 | 478.8 | 1,038.9 | 349 |
| | 478 | 586 | 108 | 27.7%<br>166-44 | 5.9%<br>35-26 | 4.3%<br>25-50 | 52.8%<br>318-08 | 4.4%<br>26-23 | 3.6%<br>21-48 | 1.3%<br>7-51 | 3,049 | 6,200 | 15 | 223.6 | 5,575 | 349.9 | 354.9 | 917.5 | 292 |
| October .... | 586 | 642 | 56 | 41.5%<br>58-45 | 6.5%<br>9-10 | 3.1%<br>4-25 | 37.9%<br>53-48 | 1.4%<br>2-00 | 9.1%<br>12-57 | 0.5%<br>0-45 | 2,512 | | 6 | 79.1 | 2,096 | 121.6 | 134.3 | 163.3 | 71<br>104† |

*In August total drilling record was not kept but only for 123.2 mach. shift of the 308.3. †In Oct. the 104 trammer was at chute at raise bottom.

off, so as to make it safe for muckers working at the bottom of the first part, the machines were set up again and drilling started. Extreme care must be taken that no steel or other articles are allowed to slip over onto the heads of the muckers.

For some time there has been a controversy as to whether it is more economical for the machine men after they have finished blasting to be placed drilling elsewhere and let muckers do the shoveling, thereby saving on the cost of shoveling, or whether the machine men should do their own mucking. The method described above is a sort of compromise between the two plans.



Figs. 1 to 3—Shaft Sinking Methods in Ontario.

## II.

## Method of Sinking Shaft of Creighton Mine, Massey, Ontario, Canada.

The method of drilling the round in this shaft was very similar to that of the Crean Hill shaft, but the ground was taken out in one part and not in two, as in the first case. The greatest contrast in the two methods, however, is in the way of handling the muck. In the case of the Crean Hill shaft the bucket was pulled up on a trolley running on a cable on the hanging wall. In the present case the bucket was run on skids on the footwall. The shaft was inclined at 47 degrees. This was not the case of a new shaft being sunk, but of a working shaft being deepened. The work was started at the eighth level. The shaft was a four-compartment working, with two skipways, a cage compartment and a ladder and pipeway. The ore skips were loaded at the seventh level, and therefore a rock prentise was left to protect the men working at the sinking. To raise the muck from the sinking operations two buckets were used, and air hoist operated each bucket; that is, two hoists were used, and they were located on the eighth level. One hoistman was able to attend to both hoists. For the skips the two center compartments were used and the prentise left under these. The buckets therefore worked one in each of the end compartments, which explains why two hoists were necessary. One of these end compartments was the ladderway and by moving the ladder over to the wall it was possible to operate the bucket in it. The other end compartment was the cageway. The cage was not run below the sixth level, which made the use of the other end compartment by the second bucket possible.

In the footwall of the shaft above the eighth level and below the ore pockets where the skips loaded a pocket was raised from a drift run in behind the shaft on the eighth level. This pocket was divided into three parts, the center part corresponding to the two skipways and each side part being arranged so that the buckets from the shaft could dump into them. The buckets dumped automatically, so that no attendant was necessary. At the bottom of the pocket chutes were built and the rock drawn off into cars and trammed to the regular rock pocket on the eighth level and hoisted with the other development rock. In this way the hoisting of ore was not interfered with. The center part of the pocket caught spillage from the loading of the skips. The diagram, Fig. 2, makes quite plain this method of handling the

SHAFT, CREIGHTON MINE, CANADIAN COPPER CO.

| (8-hr.). | | | | Drilling. | | | Mucking. | | | | | Averages. | | Shifts, labor per foot advance. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bosses. | Nippers. | Hoistmen. | Timbermen. | Feet drilled per mach. shift. | Ft. advance per drill shift. | Ft. advance per round. | Average skip capacity. | Average time per skip. | Skips per hour mucking. | Per cent time loading. | Per cent time hoisting. | Average tons per ft. advance. | Tons mucked per mucker shift. | Drillers. | Helpers. | Muckers. | Surface trammers. | Bosses. | Nippers. | Hoistmen. | Timbermen. | Bonus, per cent. | Remarks. |
| 99 | 89 | 79 | 109.6 | 21.7 | 0.41 | 7.0 | 1.19 | 7.0 | 8.4 | 71.3 | 28.7 | 28.5 | 3.63 | 4.1 | 4.1 | 7.8 | 2.9 | 0.8 | 0.7 | 0.6 | 0.87 | 26 | |
| 95 | 90 | 90 | 76.9 | 24.8 | 0.50 | 7.0 | 1.37 | 7.1 | 8.4 | 72.2 | 27.8 | 28.5 | 4.01 | 3.3 | 3.3 | 7.1 | 2.4 | 0.7 | 0.6 | 0.6 | 0.52 | 46 | |
| 81 | 75 | 75 | 97.6 | 24.9 | 0.48 | 7.2 | 1.37 | 6.3 | 9.5 | 67.8 | 32.2 | 37.8 | 5.74 | 3.2 | 3.3 | 8.5 | 2.7 | 0.8 | 0.8 | 0.8 | 0.90 | 30 | Top row of figures applies before the shaft reached raise No. 32, and bottom row after shaft reached the raise. |
| 20 | 18 | 18 | 12.0 | 26.5 | 0.71 | 9.3 | | | | | | | | 2.2 | 2.4 | 2.9 | 3.1 | 0.4 | 0.3 | 0.3 | 0.21 | | |

rock broken in sinking operations while regular work is going on.

### III.

### Method of Sinking Dime Mine Incline, South Porcupine, Ontario.

This method is for a very flatly inclined shaft, and, while classed under shaft sinking, the shaft was in reality raised. The inclination was about 10 degrees. The size of the shaft was 12x8 ft. In each round 32 holes were drilled. Referring to Fig. 3, it will be seen that there were five holes in each side of the cut and that the center cut was used. These holes are numbered 1. For the holes on each side of the cut only four were found necessary in each row, except in the side holes, where only three were necessary. This gave the back of the incline a fair arch. Two machines were employed, one drilling each side of the round, and both working off the same bar. About 5 or 6 ft. was pulled in a round and 25 ft. per week was considered a fair rate of advance. The cut was fired first, for it is necessary to draw the cut out well before the rest of the round can do the best work with the least powder possible. If the cut broke well the rest of the round was then fired, but if by any chance the cut failed to come it was blasted a second time. After the incline had advanced a short distance a great deal of time was lost after blasting, due to the gas and smoke which prevented the men from returning to the face. The air was always turned on in the machine hoses, which were dragged to the face as soon as possible, but this was not a very effective way to blow out the smoke. Various means were considered to lessen the time lost due to blowing smoke, and finally a water hose was decided upon. A line was run from the pump at the sump and the valve for turning the water into the face was at the pump. Before blasting the water hose with its nozzle was set pointing toward the face a short distance from it and some muck put on it to keep it in place while blasting was in progress and to protect the hose from flying rock. Just the nozzle was exposed. After the holes had been lighted for a short time, so that there would be no danger of the water causing a misfire by playing on a fuse, the valve at the pump was opened. About five minutes after the last hole had exploded the men returned to the incline and dragged the hose to the face, spraying all the walls and muck. While before the use of the water it had been necessary to wait probably an hour before it was possible to start and set up the bars for the drilling of the next round, after the water had been introduced the setting up started in about 10 minutes.

The machine men did no mucking. A small air hoist was placed at the bottom of the incline and was operated by one of the trammers. An extra bar was set up a short distance behind the machine bar and a block fastened to it. A cable run through the block was attached to the car, which was pulled up the incline by the air hoist below. One-ton cars were used. It was found that two cars could be run in tandem without any trouble, which gave the trammers more room to work in and gave quicker handling of the muck. The cars being loaded were lowered down the incline to the level below and trammed to the working shaft and hoisted on the cage.

### IV.

### Method of Sinking Shaft 3, Creighton Mine, Massey, Ontario.

This shaft was a new shaft sunk from surface and at present writing has not been completed. The work in this shaft has been remarked upon in various technical magazines because of the speed that was attained, and while the speed did not come up to that of the new shaft of the Newport Mine at Ironwood, Mich., nevertheless the work ranks with the best done in America and surpasses all records of the district. The shaft was 33x8 ft. and inclined at 55 degrees. All the mucking was done by machine men, but the mucking differed from the examples described in the first parts of this article in that no bucket or car was resorted to, but a good temporary headframe was erected as soon as the shaft had gotten through the broken surface rock and a good solid rock was reached. At this time the sinking work was suspended and a concrete collar was put in, as well as the headframe and a two-drum hoist. The hoist was electrically driven. The whole sinking rig was superior to many permanent hoisting rigs at smaller mines. Mucking was done directly into the skips. The skips dumped automatically in the headframe rock bin. The same type of cut as that employed at Crean Hill was used, but the shaft was sunk all in one part. This is the double cut in the center of the shaft. Blasting was done electrically from the lighting circuit and the cut was fired first, after which it was mucked out and the rest of the round fired and mucked. Usually two blasts were sufficient, but occasionally three were necessary. Three bars were used on each side of the shaft, each bar carrying two machines, making a total of 12 machines. Canadian Ingersoll-Rand No. 43 piston machines were employed. It might be noted as a matter of interest in passing that so many machines operating in so small an enclosed space made a noise that was deafening and many of the men stuffed their ears before going to work. The round pulled ranged all the way from 6 to 10 ft., but averaged up about 7 ft. Complete and accurate figures were kept of all operations and one man was employed each shift that did nothing but keep the log of operations. This information was handed over to the engineering department and an elaborate daily report was kept, from which a monthly sheet was prepared. The figures for several months are shown in the accompanying Table 1.

The shaft was sunk in granite most of the way. Considerable time was lost blowing smoke until the shaft had advanced far enough to enable a connection to be made to one of the levels which furnished a good draft. At the eighth level a drift was run into the line of the shaft and a raise was put up to meet the shaft above. Chutes were constructed at the raise bottom, with the idea that muck could be drawn off here after the raise met the shaft and that the machine men could employ all their time drilling. After the shaft met the raise the work approached stoping in nature, and it was thought that great speed would be attained at this point. The raise was not put up the full size of the shaft, it is to be understood, but was only about 5x5 ft., and the rest of the shaft was stoped into it. The raise proved to be rather small and the muck could not be drawn off quickly enough, so that considerable mucking had to be done by the machine men after all. The raise choked up once or twice and had to be blasted down, so that on the whole this raise did not justify any similar raises from lower points. True, a few additional feet were gained in the rate of advance, but the rock drawn off through the raise had to be handled through the main working shaft, and this interfered with the ore output.

No figures are available on the cost of this work. It took 8 to 10 hours to drill off the round and about 24 hours to muck it out and blast. The table shows the percentages of time consumed in the various operations.

## BLASTING BOULDERS AND ROCK LEDGES.

Contributed by Thomas M. Knight, E. I. Dupont De Nemours Co., Wilmington, Del.

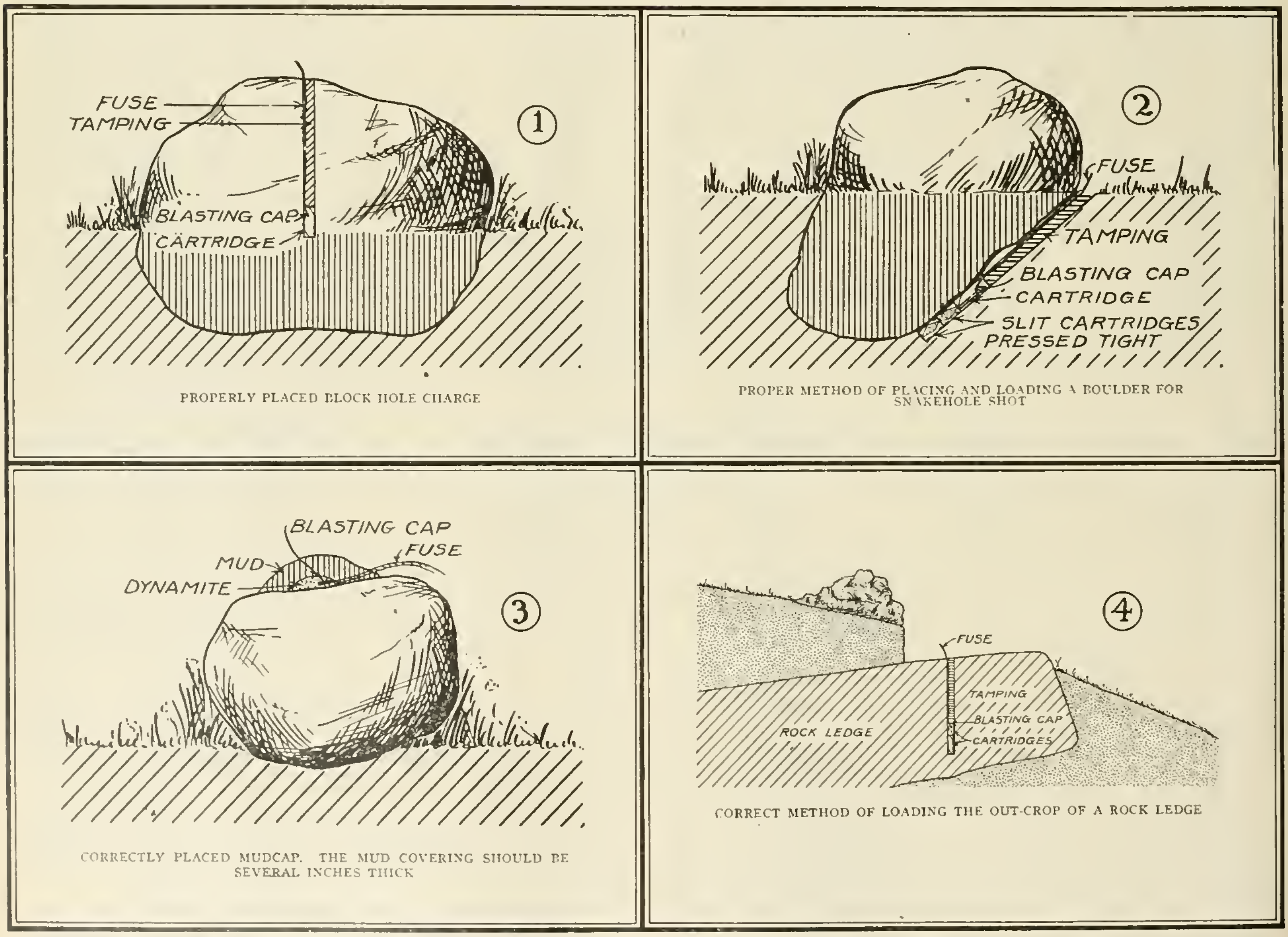
There are three distinct methods successfully employed today in the blasting of boulders from building sites or railroad and highway right-of-ways. These are blockholing, snakeholing, and mudcapping. A shot combining both snakeholing and mudcapping is sometimes made on very large boulders where it is not practical to drill into the rock for a blockhole shot.

Of these methods employed, blockholing requires the least amount of dynamite, but calls for the greatest amount of labor. Mudcapping demands the greatest amount of dynamite and the least amount of labor and time, while snakeholing lies between the two, as it requires a moderate amount of both dynamite and labor.

Probably the best way to break up very hard boulders is by the blockhole method. This consists in boring a hole about 1¼ in. in diameter about half way through the boulder. The dynamite used should be removed from the cartridge and packed firmly into the bottom of the hole. A small hole is made in this firmly pressed dynamite with a sharp stick, and in this is inserted a blasting cap and fuse. The hole is then tamped full of moist earth. Care should be taken to have this tamping material packed very firmly (see Fig. 1). The gases caused by the explosion are so perfectly confined by this method that excellent results may be secured with a comparatively small amount of a low strength dynamite. A glance at the accompanying Table I shows that it requires only about one-eighth as much dynamite to break a boulder this way as it would to break it by mudcapping.

TABLE I.—SHOWING THE APPROXIMATE AMOUNT OF DYNAMITE REQUIRED TO BREAK BOULDERS, BASED ON USING A 50% STRENGTH STRAIGHT NITROGLYCERINE DYNAMITE.

| Diameter of Boulder in Feet. | Number of Cartridges Required— Mudcapping. | Snakeholing. | Blockholing. |
|---|---|---|---|
| 1½ | 2 | 1 | ¼ |
| 2 | 3 | 1 | ¼ |
| 3 | 4 | 1½ | ½ |
| 4 | Don't attempt | 4 | ¾ |
| 5 | Don't attempt | 6 | 1 |



PROPERLY PLACED BLOCK HOLE CHARGE

PROPER METHOD OF PLACING AND LOADING A BOULDER FOR SNAKEHOLE SHOT

CORRECTLY PLACED MUDCAP. THE MUD COVERING SHOULD BE SEVERAL INCHES THICK

CORRECT METHOD OF LOADING THE OUT-CROP OF A ROCK LEDGE

Fig. 1—Properly Placed Blockhole Charge.
Fig. 3—Correctly Placed Mudcap.

Fig. 2—Proper Method of Placing and Loading a Snakehole.
Fig. 4—Blasting Outcrop Ledge.

In breaking a boulder by the snakehole process, a hole is punched down with a bar directly under but along side of the boulder (see Fig. 2). The hole should be punched deep enough so that the charge of dynamite will rest directly under the heaviest part of the boulder. The dynamite cartridges are placed in the bore hole in as compact a position as possible, and to secure this the cartridges are generally slit. A primer is inserted and the bore hole packed tightly with a moist, plastic material. Blasts of this sort are generally fired with blasting cap and fuse. A 40 per cent Extra dynamite is best suited for work of this sort. Electric blasting is not generally resorted to unless the boulder is very large and two or more shots are required.

Some people use this method of blasting to lift the boulder out of the ground and then break it up with a mudcap. The boulder may be lifted out readily by following the method just described, the only difference being that a smaller amount of dynamite is used.

Mudcapping (Fig. 3), is the easiest method of all. While it requires the most dynamite of any, yet it is not necessarily the costliest, as the saving of time and labor goes a long way toward paying for the extra dynamite that is required.

In mudcapping, the dynamite is taken from the cartridge and is placed on the boulder in a conical shaped pile just where the boulder would be hit with a sledge, if it were possible to break it in this manner. The explosive is packed down firmly and a blasting cap and fuse is put in the top of this miniature pyramid. A covering of thick, plastic mud must be placed over this dynamite. This should be at least five or six inches in thickness. Care should be observed to see that this mud covering is free from stones or other heavy matter, as the force of the explosion will throw such material at terrific speed. A stone or plank should never be placed on top of the mudcap for the same reason.

A quick-acting dynamite is required for this class of work, and the Extras or a Straight Nitroglycerine dynamite will produce the best results. A 40 per cent Extra will be found satisfactory on easily broken rock, but on very hard rock a 50 per cent Straight dynamite will be required.

If a portion of the boulder extends into the ground, do not try to break it by mudcapping, as the confining dirt makes it harder for the explosives to do their work. In cases of this sort the boulder may be rolled out by a snakehole shot and then broken by mudcapping.

When blasting boulders near a highway or railroad where there is more or less travel, it will probably be better to fire the charges electrically. This has the advantage over the blasting cap and fuse insomuch that the exact instant of explosion is under the control of the operator of the blasting machine, and the charge may be fired at the moment desired.

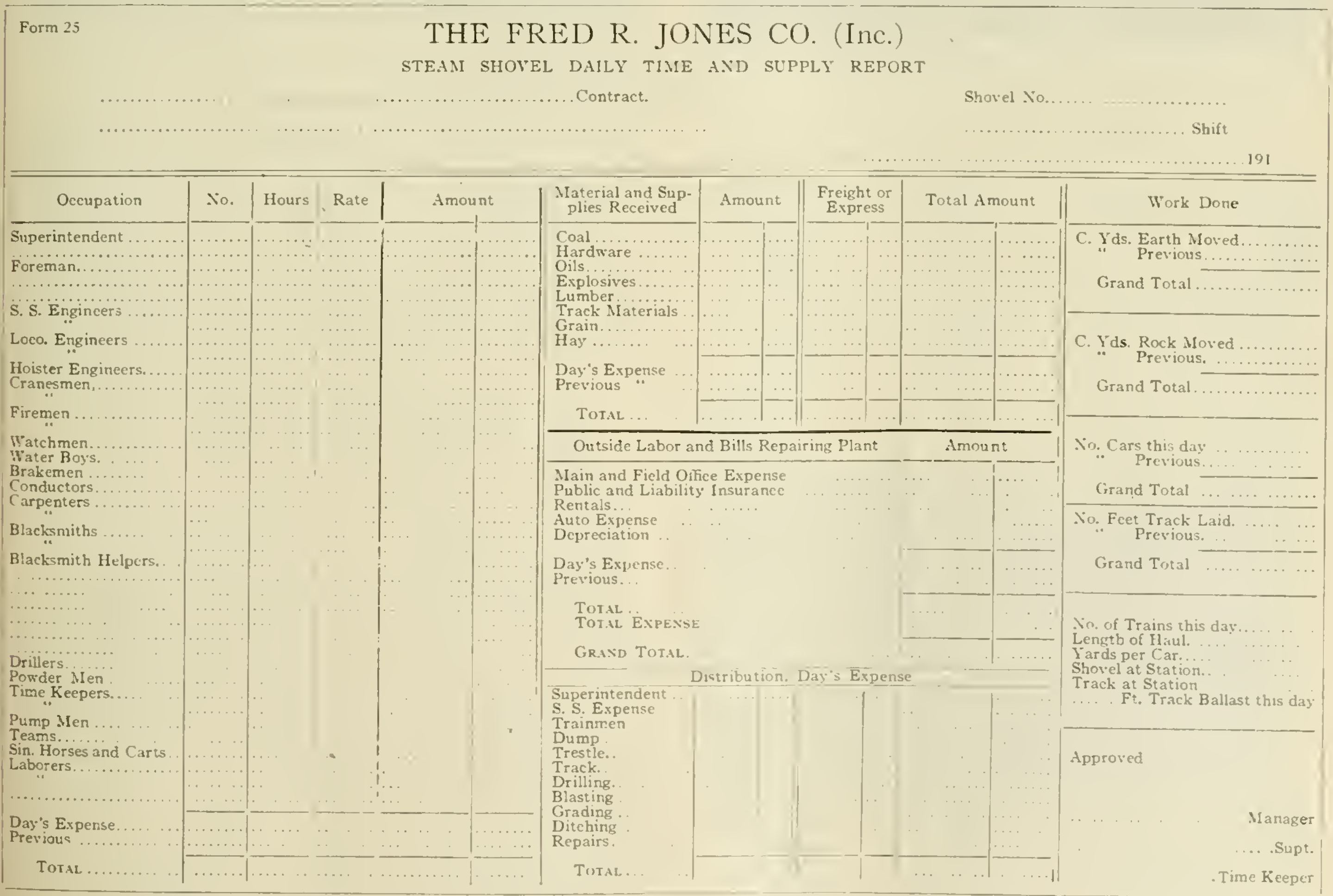
For very large boulders where it is not practical to drill into them, they may be broken up by a combination snakehole and mudcap shot. This may be accomplished by placing a large mudcap charge on top of the boulder and one or more snakehole charges, depending on the size and shape of the boulder. These are connected up and fired electrically. The force of the explosions on two sides of the boulder at the same time greatly increases the shock and does better and more effectual work than by either one of the methods alone.

In blasting off rock ledges as shown in Fig. 4, the dirt is first cleared off and a bore hole put down and fired as in an ordinary blockhole shot. If the ledge is wide, then a series of holes are put down extending clear across the ledge. The holes are loaded, connected up, and fired by the electric method.

## DAILY REPORT FORM FOR STEAM SHOVEL AND DRAG LINE EXCAVATION WORK.

Contributed by Fred R. Jones Co., Contractors, Chicago, Ill.

The report illustrated is made out by our field office the first thing each morning following the previous day's work. One copy is retained for the field file and the other is sent in to this office. You will note the total days' expense as well as the total labor expense to date is carried forward and included with the total supply and other miscellaneous expenses to form the grand total expense marked "X." By use of these reports we are enabled to keep a close watch on the daily output as well as the daily expense, and we can tell each day just how the contract stands for the month. We use this report on our steam shovel and dragline excavation work, but have another similar form for other classes of work we might have under contract, but all based on this original outline.



Form 25

THE FRED R. JONES CO. (Inc.)

STEAM SHOVEL DAILY TIME AND SUPPLY REPORT

.......................... Contract. Shovel No. ..........

.......................... Shift

.......................... 191

| Occupation | No. | Hours | Rate | Amount |
|---|---|---|---|---|
| Superintendent | | | | |
| | | | | |
| Foreman | | | | |
| | | | | |
| | | | | |
| S. S. Engineers | | | | |
| " | | | | |
| Loco. Engineers | | | | |
| " | | | | |
| Hoister Engineers | | | | |
| Cranesmen | | | | |
| " | | | | |
| Firemen | | | | |
| " | | | | |
| Watchmen | | | | |
| Water Boys | | | | |
| Brakemen | | | | |
| Conductors | | | | |
| Carpenters | | | | |
| " | | | | |
| Blacksmiths | | | | |
| " | | | | |
| Blacksmith Helpers | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Drillers | | | | |
| Powder Men | | | | |
| Time Keepers | | | | |
| " | | | | |
| Pump Men | | | | |
| Teams | | | | |
| Sin. Horses and Carts | | | | |
| Laborers | | | | |
| " | | | | |
| | | | | |
| Day's Expense | | | | |
| Previous | | | | |
| TOTAL | | | | |

| Material and Supplies Received | Amount | Freight or Express | Total Amount |
|---|---|---|---|
| Coal | | | |
| Hardware | | | |
| Oils | | | |
| Explosives | | | |
| Lumber | | | |
| Track Materials | | | |
| Grain | | | |
| Hay | | | |
| Day's Expense | | | |
| Previous " | | | |
| TOTAL | | | |

| Outside Labor and Bills Repairing Plant | Amount |
|---|---|
| Main and Field Office Expense | |
| Public and Liability Insurance | |
| Rentals | |
| Auto Expense | |
| Depreciation | |
| Day's Expense | |
| Previous | |
| TOTAL | |
| TOTAL EXPENSE | |
| GRAND TOTAL | |

| Distribution. Day's Expense | | |
|---|---|---|
| Superintendent | | |
| S. S. Expense | | |
| Trainmen | | |
| Dump | | |
| Trestle | | |
| Track | | |
| Drilling | | |
| Blasting | | |
| Grading | | |
| Ditching | | |
| Repairs | | |
| TOTAL | | |

Work Done

C. Yds. Earth Moved ..........
" Previous ..........
Grand Total ..........

C. Yds. Rock Moved ..........
" Previous ..........
Grand Total ..........

No. Cars this day ..........
" Previous ..........
Grand Total ..........

No. Feet Track Laid ..........
" Previous ..........
Grand Total ..........

No. of Trains this day ..........
Length of Haul ..........
Yards per Car ..........
Shovel at Station ..........
Track at Station ..........
..... Ft. Track Ballast this day

Approved

.......... Manager
.......... Supt.
.......... Time Keeper

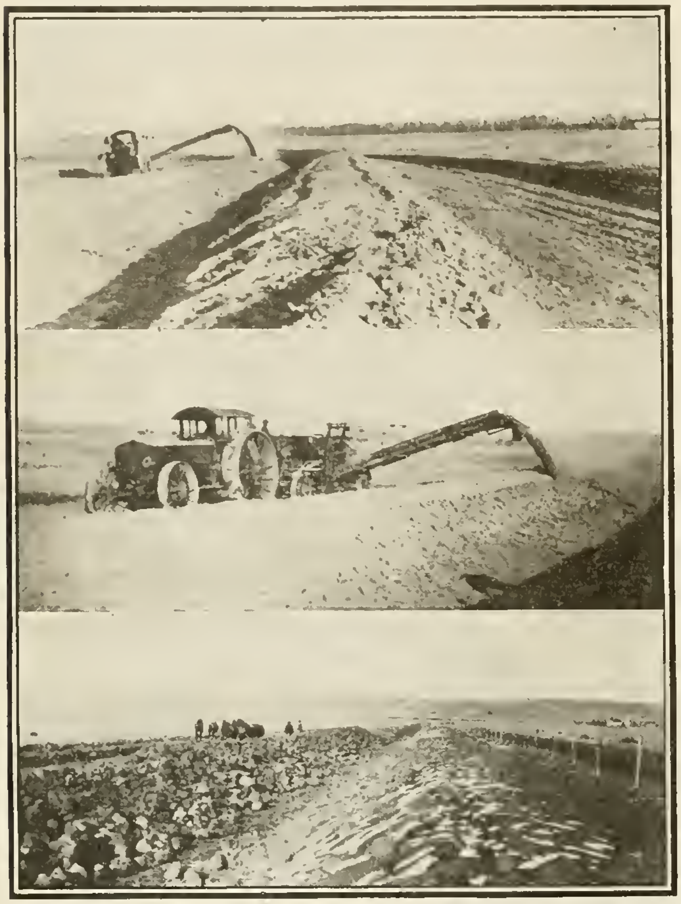
Form for Recording Steam Shovel Excavation.

## COST OF EARTH WORK OF THE SECOND UNIT OF THE DODSON NORTH CANAL, MILK RIVER PROJECT, MALTA, MONT.

Contributed by A. E. Bechtel, Salt Lake City, Utah.

The earth work of the second unit of the Dodson North Canal, Milk River Irrigation Project, near the town of Malta, Mont., was done by contract under the direction of the United States Reclamation Service, C. H. Schlect, Project Manager, and F. O. Hansen, Superintendent of Construction for the Service. Work was begun on Sept. 1, 1913, and completed on Sept. 1, 1914. There were 230,000 cu. yd. of excavation in canals and 70,000 cu. yd. in waste water ditches. The canals were from 5 to 10 ft. bottoms with a slope of 2 to 1, and contained from 100 cu. yd. to 1,300 cu. yd. to the station averaging about 400. Approximately 20,000 cu. yd. was wet and 30,000 cu. yd. was hillside work.

The waste water ditches had from 3 ft. to 20 ft. bottoms (mostly 3 ft.) with a slope of 1½ to 1, and averaged about 100 cu. yd. per station; 10,000 cu. yd. was wet excavation. About 35,000 cu. yd. were cast into the canal banks with an Austin reversible elevating grader



Construction Views on Dodson Canal, Milk River Irrigation Project.

TABLE III.—COST OF EXCAVATION AND BACKFILL FOR STRUCTURES.

| Structure— | Excav. Cu yd. | Backfill. Cu. yd. | Classification. | Labor Cost Foreman. Unit. | Labor Cost Excav. Unit. | Labor Cost Backfill. Unit. | Total field cost. Unit. | Overhead Charge General Super-vision Unit. | Overhead Charge Equip-ment. Unit. | Overhead Charge Cont. Exp. Unit. | Con-tractors Total Cost. Unit. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spillway | 104.5 | ....... | Hard clay | ... | $1.04 | ... | $1.04 | $0.22 | $0.11 | $0.28 | $1.64 |
| Spillway | 78.8 | ....... | Hard clay | ... | 1.16 | ... | 1.16 | .24 | .12 | .31 | 1.84 |
| Spillway | 77.0 | ....... | Hard clay | ... | 1.13 | ... | 1.13 | .24 | .12 | .30 | 1.79 |
| Spillway | 53.6 | ....... | Hard clay | $0.17 | 1.24 | ... | 1.41 | .13 | .19 | .19 | 1.92 |
| Spillway | 104.2 | ....... | Hard clay | .06 | .47 | ... | .53 | .05 | .08 | .08 | .74 |
| Automatic way | 162.2 | ....... | Hard clay | ... | 1.08 | ... | 1.08 | .22 | .11 | .29 | 1.70 |
| Automatic way | 361.5 | ....... | Hard clay | ... | .68 | ... | .68 | .14 | .07 | .11 | 1.07 |
| Automatic way | 165.0 | 250 | Hard clay | ... | 1.28 | $0.11 | 1.39 | .25 | .16 | .32 | 2.10 |
| Automatic way | 346.0 | 500 | Hard clay | .11 | .52 | .09 | .72 | .07 | .09 | .10 | .98 |
| Automatic way | 202.1 | 250 | Hard clay | .08 | .40 | .04 | .52 | .05 | .07 | .09 | .71 |
| Automatic way | 363.0 | 200 | Wet muck | .11 | .51 | .02 | .64 | .06 | .09 | .09 | .88 |
| Spillway | 117.6 | ....... | Hard clay | ... | .99 | ... | .99 | .21 | .11 | .27 | 1.58 |
| Spillway and check | 45.4 | ....... | Light clay | ... | .23 | ... | .23 | .02 | .04 | .04 | .33 |
| Total | 2,180.9 | 1,200 | ....... | .05 | .74 | .03 | .82 | .13 | .10 | .17 | 1.22 |
| Ry. box culv. | 462.7 | 462.7 | Average clay | .04 | .44 | .10 | .58 | .05 | .07 | .07 | .77 |
| Ry. box culv. | 463.0 | 463.0 | Average clay | .04 | .42 | .11 | .57 | .05 | .08 | .07 | .77 |
| Ry. box culv. | 388.3 | 388.3 | Average clay | .02 | .49 | .15 | .56 | .09 | .10 | .10 | .85 |
| Ry. box culv. | 460.6 | 460.6 | Average clay | .02 | .37 | .09 | .48 | .04 | .06 | .06 | .64 |
| Ry. box culv. | 243.0 | 243.0 | Clay 10% wet | .05 | .47 | .19 | .71 | .07 | .10 | .09 | .97 |
| Total | 2,017.6 | 2,017.6 | ....... | .03 | .43 | .12 | .58 | .05 | .07 | .08 | .78 |
| Ry. pipe culvert, cast iron | 126.0 | 126.0 | Average clay | ... | .57 | .24 | .81 | .08 | .11 | .10 | 1.10 |
| Ry. pipe culvert, cast iron | 942.0 | 942.0 | Average clay | .01 | .15 | .03 | .19 | .02 | .02 | .03 | .26 |
| Ry. pipe culvert, cast iron | 68.0 | 68.0 | Average clay | .05 | .67 | .07 | .80 | .08 | .10 | .10 | 1.08 |
| Ry. pipe culvert, cast iron | 28.6 | 28.6 | Average clay | ... | .68 | .16 | .84 | .08 | .11 | .11 | 1.14 |
| Ry. pipe culvert, cast iron | 63.2 | 63.2 | Average clay | .04 | .41 | .20 | .65 | .07 | .09 | .09 | .88 |
| Total | 1,227.8 | 1,227.8 | ....... | .01 | .24 | .07 | .32 | .03 | .04 | .04 | .43 |
| 2′-6″x3′ conduit | 615.5 | 100.0 | Sandy clay | ... | .15 | .05 | .20 | .02 | .02 | .03 | .27 |
| Steel flume | 170.0 | 20.0 | Gumbo | .11 | .64 | .01 | .76 | .07 | .10 | .10 | 1.03 |
| V. P. culvert under canal | 105.7 | 105.7 | Gumbo | ... | ... | ... | 1.24 | .26 | .12 | .33 | 1.95 |
| V. P. culvert under canal | 308.0 | 308.0 | Gumbo | ... | .09 | .22 | .31 | .03 | .04 | .04 | .42 |
| V. P. culvert under canal | 91.2 | 91.2 | Clay and gumbo | ... | .24 | .18 | .42 | .04 | .05 | .05 | .56 |
| V. P. culvert under canal | 183.2 | 183.2 | Clay and gumbo | ... | .13 | .10 | .23 | .03 | .02 | .04 | .32 |
| V. P. culvert under canal | 125.3 | 125.3 | Clay and wet sand | ... | ... | .15 | .63 | .06 | .08 | .09 | .86 |
| V. P. culvert under canal | 127.2 | 127.2 | Gumbo | ... | .69 | .12 | .81 | .08 | .11 | .11 | 1.11 |
| Total | 940.6 | 940.6 | ....... | ... | .31 | .21 | .52 | .06 | .06 | .09 | .73 |
| Concrete turnout | 60.7 | 60.7 | Sandy clay | ... | .07 | .14 | .20 | .02 | .03 | .02 | .27 |
| Concrete turnout | 41.1 | 44.1 | Sandy clay | ... | .14 | .05 | .20 | .02 | .02 | .02 | .26 |
| Total | 104.8 | 104.8 | ....... | ... | .10 | .10 | .20 | .02 | .02 | .02 | .26 |
| 5′-4″ pressure pipe | 2,341.3 | 500.0 | Light clay | .03 | .22 | .04 | .29 | .02 | .04 | .04 | .39 |
| Concrete checks | 20.8 | ....... | Light clay | ... | .17 | ... | .17 | .01 | .03 | .03 | .24 |
| Bridge apps. | 2,566.4 | ....... | Average clay | ... | .32 | ... | .32 | .02 | .03 | .03 | .40 |
| Turnouts and checks | 1,426.5 | 1,426.5 | Average clay | ... | .29 | .14 | .43 | .04 | .06 | .06 | .57 |
| Outlet, corrugated pipe | 470.0 | 470.0 | Light clay | ... | .33 | .22 | .55 | .09 | .06 | .12 | .82 |
| Outlet, corrugated pipe | 548.0 | 548.0 | Light clay | ... | .21 | .24 | .45 | .06 | .04 | .07 | .62 |
| Outlet, corrugated pipe | 650.0 | ....... | Light clay | ... | .25 | ... | .25 | .03 | .03 | .03 | .34 |
| Outlet, corrugated pipe | 650.0 | 650.0 | Light clay | ... | .26 | .12 | .38 | .04 | .05 | .05 | .52 |
| Total outlets | 2,318.0 | 1,658.0 | ....... | ... | .26 | .13 | .39 | .05 | .05 | .06 | .55 |
| G. N. Y. track | 1,734.0 | ....... | Hard clay | ... | .35 | ... | .35 | .03 | .05 | .05 | .48 |
| Total structures | 17,664.2 | 8,115.3 | ....... | .02 | .35 | .07 | .44 | .05 | .05 | .07 | .57 |

TABLE I.—COST OF CANAL AND DITCH EXCAVATIONS IN 1913.

| Quantity, Cu. yd. | Labor. | Teams. | Gas and oil. | Re-pairs. | Supt. | Equip. | Cont. Exp. | Total cost. | No. |
|---|---|---|---|---|---|---|---|---|---|
| 13,192.. | $0.082 | $0.063 | ...... | ...... | $0.024 | $0.009 | $0.027 | $0.210 | 1 |
| 10,420.. | .126 | .070 | ...... | ...... | .032 | .014 | .037 | .282 | 2 |
| 10,000.. | .052 | .... | $0.033 | $0.013 | .008 | .004 | .009 | .119 | 3 |
| 5,651.. | .240 | .156 | .... | .... | .061 | .027 | .073 | .557 | 4 |
| 10,776.. | .065 | .... | .033 | .013 | .009 | .005 | .011 | .133 | 5 |
| 9,735.. | .093 | .105 | .... | .... | .032 | .013 | .037 | .267 | 6 |
| 11,600.. | .080 | .105 | .... | .... | .029 | .013 | .034 | .259 | 7 |
| 6,665.. | .055 | .055 | .... | .... | .018 | .007 | .021 | .154 | 8 |
| 1,817.. | .065 | .035 | .... | .... | .016 | .007 | .018 | .141 | 9 |
| 7,291.. | .043 | .059 | .... | .... | .016 | .007 | .019 | .144 | 10 |
| 17,483.. | .065 | .074 | .... | .... | .022 | .008 | .025 | .192 | 11 |
| 5,395.. | .096 | .098 | .... | .... | .031 | .013 | .031 | .269 | 12 |
| 6,900.. | .038 | .... | .033 | .013 | .006 | .003 | .007 | .100 | 13 |
| 5,600.. | .092 | .... | .033 | .013 | .006 | .003 | .007 | .154 | 14 |
| 880.. | .077 | .... | .033 | .013 | .006 | .003 | .007 | .139 | 15 |
| 12,022.. | .... | .... | .... | .... | .... | .... | .... | .125 | 16 |
| 134,547.. | .... | .... | .... | .... | .... | .... | .... | .213 | Totl. |

*Note—Fresno work Nos. 1, 6, 7, 8, 9, 10, 11, 12 and 16; excavation work Nos. 3, 5, 13, 14 and 15; slip work No. 2; wheeler work No. 4.

TABLE II.—COST OF CANAL AND DITCH EXCAVATION IN 1914.

| | Cu. yd. | Unit cost. |
|---|---|---|
| Team Work— | | |
| Superintendence | ....... | $0.0100 |
| Foreman | ....... | 0.0114 |
| Plow | ....... | 0.0160 |
| Fresno | ....... | 0.0771 |
| Blacksmith | ....... | 0.0012 |
| Fence and grubbing | ....... | 0.0005 |
| Finishing | ....... | 0.0028 |
| Equipment, hardware and tools | ....... | 0.0161 |
| General expense | ....... | 0.0038 |
| Labor, erecting, moving and maintaining camp | ....... | 0.0014 |
| Cook | ....... | 0.0044 |
| Labor, Hauling camp and stable supplies | ....... | 0.0020 |
| Labor, maintaining stable | ....... | 0.0036 |
| Total, teams | 93,949 | 0.1503 |
| Machine Work— | | |
| Superintendence | ....... | 0.0024 |
| Labor | ....... | 0.0302 |
| Gas and oil | ....... | 0.0297 |
| Repairs | ....... | 0.0188 |
| Equipment, hardware and tools | ....... | 0.0683 |
| Total machine | 22,175 | 0.1494 |
| Total— Machine and Teams | 116,124 | 0.1501 |
| Sub-Contractors— | | |
| E A. Higgins | 7,343 | 0.119 |
| Broderick & Morrow | 11,030 | 0.152 |
| Congatton, Denning & Munsen | 23,856 | 0.066 |

The machine consisted of a Reversible Austin Elevating Grader and Pioneer Tractor.

pulled by a 30-60 h.p. Pioneer gas tractor, and 25,000 cu. yd. of the excavation of the waste water ditches were cast out with an Austin senior elevating grader. These machines were operated two and three shifts during the fall of 1913 and one shift during 1914.

The remainder of the work, 240,000 cu. yd., was done with 5 ft. Fresnoes, excepting the finishing of the waste water ditches, which was done with drag scrapers, and about 5,000 cu. yd. of over-haul done with wheelers. About 60,000 cu. yd. of the work was sub-contracted but the costs here are the costs to the sub-contractors. The costs on excavation are separated for the work done in 1913 and 1914.

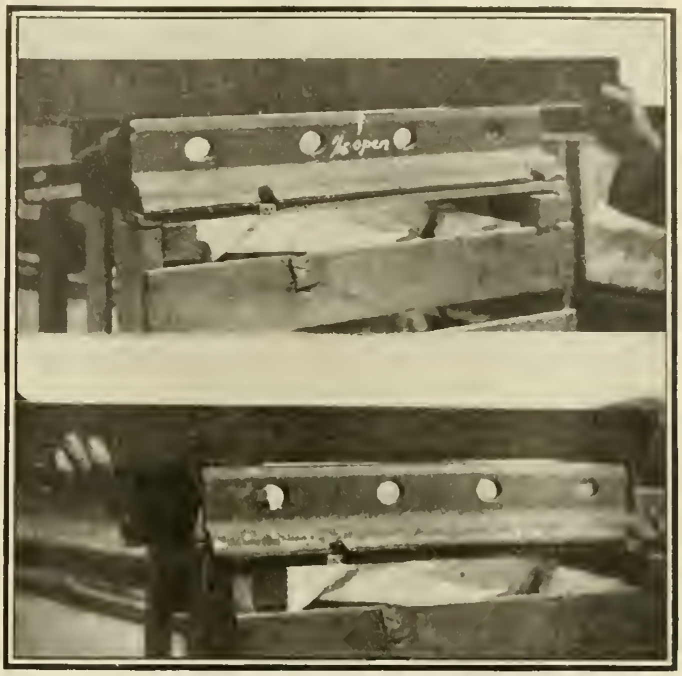
The material excavated in the canals and laterals, other than that designated as wet, was average clay soil with more or less gumbo. The waste water ditches were mostly gumbo and baked so hard that in excavating it with a grader, it was hard to keep the plow in the ground.

## METHOD OF ELIMINATING LOW JOINTS IN TRACK LAID THROUGH STRETCH OF OCEAN BEACH SAND.

Contributed by Clifford A. Elliott, Maintenance of Way Department Pacific Electric Railway Co., Los Angeles, Cal.

In the maintenance of one of the Pacific Electric Railway Co.'s interurban lines in Southern California, constructed for considerable distance along the beach of the Pacific Ocean, a great deal of trouble is experienced with low joints due to the construction being through heavy beds of ocean sand.

Several remedial measures have been adopted by replacing angle bars with continuous joints with view of obtaining a firmer and stiffer joint support—in addition to thorough joint tie tamping. However, this scheme has proven unsuccessful, as the heavy traffic has caused the metal of the unresistible continuous joint to arch downward to considerable extent, with result that low joints are exceptionally evident; and surface bent rails are very prominent. A novel plan to remedy the situation has been resorted to, by removing the old continuous joints and arching them from 1/16 in. to 3/16 in.—a method reversely to the unfavorable conditions experienced as above mentioned. Some 1,200 pairs of continuous joints were so adjusted, reapplied and raised, and since September, 1915, when the work was performed, fully 95 per cent of the joints have given no evidence of failing. At the same time, this remedy affords the continuous joint the opportunity to perform the true function expected of it—even when stable support is not entirely afforded, further holding the track in first class surface and alinement.



Repairing Low Rail Joints by Arched Fish Plates.

This plan has realized the saving of the expense for new joints to replace the old damaged joints, which were cleaned, repaired and arched. However, had not this action been taken in the manner herein cited at the logical time, the old joints would soon have been declared only fit for the scrap pile. Besides this procedure has been instrumental in reducing maintenance expense for excessive track labor upon part of forces, endeavoring to hold the sandbed constructed track in proper surface and line. Also, it eliminates low joints and badly surface-bent rail.

## A STEAM-OPERATED CLAMSHELL BUCKET FOR BASEMENT EXCAVATION.

Contributed by J. W. Cunningham, Portland, Ore.

For basement excavation in Portland, Oregon, where the material to be handled is a heavy clay soil and cannot be readily handled by the ordinary forms of bucket, Mr. C. J. Cook of the C. J. Cook Co., has developed a clamshell bucket of special design, closed by a small two-cylinder steam engine. The bucket used is a modified "Williams."

Cellar Excavation With Steam Closing Clamshell.

The engine drives a pair of differential drums through gearing, giving and exceptionally powerful closing motion. For basement work the bucket is handled by a revolving crane supported at street level, the boiler of which also supplies the bucket. The spoil is delivered to dump wagons through a trap platform which was illustrated in a recent number of Engineering-Contracting.

**Conference on Brick Pavement Construction.**—Further details regarding the annual meeting and conference of the National Paving Brick Manufacturers' Association, which is to be held at Terre Haute, Ind., and Paris, Ill., on Oct. 5 and 6, is now available. The sessions of the annual meeting will take place at the Deming Hotel, Terre Haute, Ind., Oct. 5, 1916, at 10 o'clock a. m. The construction demonstration will take place at Paris, Ill., Oct. 6. At 9 a. m., Oct. 6, a short inspection trip will be made over some of the old Terre Haute brick paved streets, particularly S. Sixth St. At 10 a. m. the entire conference will go by interurban to Paris, Ill., at which place some of the older streets will be inspected; will be conveyed in automobiles to the point of construction demonstration, which is to be the special feature of the occasion.

## PERSONALS.

George J. Percival has been appointed Engineer of the Philadelphia office of the F. W. Mark Construction Co., Cleveland, O.

L. P. Scott, of the Bureau of Roads of the Illinois Highway Department, has been appointed maintenance engineer with headquarters at Aurora, Ill.

John E. Meyer, formerly Assistant to James Reynolds, Civil Engineer, Redwood Falls, Minn., has opened an engineering office at Montevideo, Minn.

Joseph K. Gannett, Assistant Chief Engineer of the Samuel Austin & Son Co., contractors, Cleveland, O., has been appointed Chief Engineer of the Philadelphia branch of the company. Robert E. Bell succeeds Mr. Gannett as Assistant Chief Engineer.

J. Albert Holmes, formerly Division Engineer in charge of construction of the Charles River Dam has been appointed Resident Engineer for the J. G. White Engineering Corp., New York City, for the construction of earth dams near Bridgewater, N. C., for the Southern Power Co.

G. C. Peterson has resigned his position as Highway Commissioner of Sheboygan County, Wis., and has accepted the position of manager of a railroad in Santo Domingo, West Indies. Mr. Peterson who was employed as Civil Engineer on the Panama Canal for two years, was later Engineer in charge of the work of construction on the road he is now to manage.

F. B. H. Paine, William McClellan and Horace T. Campion have entered into a partnership under the firm name of Paine, McClellan & Campion, with offices at 25 Church St., New York, and 1420 Chestnut St., Philadelphia. Mr. Paine has had a consulting engineer practice with offices in New York City since 1911. Mr. Campion, formerly was in charge of the Philadelphia office of the Reinforced Concrete Construction Co , and later was associated with Mr. McClellan in a construction and consulting engineering business. Mr. McClellan is director of the Wharton School of Finance.

The College of Engineering of the University of Illinois reports the following new appointments to its staff, effective Sept. 1, 1916:

### Department of Architecture.

Cyrus Edmund Palmer as instructor in architectural engineering. Graduated from the University of Illinois in 1912 with the degree of Bachelor of Science, and received the degree of Master of Science from Pennsylvania State College in 1916. Since 1912 assistant and instructor in architectural engineering at the Pennsylvania State College.

Owen James Trainor Southwell as instructor in architectural design. Graduated from the Carnegie Institute of Technology in 1915 with the degree of Bachelor of Architecture; carried graduate work in architecture part time during the year 1915-16; awarded first mention placed class of Beaux Arts, American institute of architects scholastic medal, 1915, third medal in archaeology, Beaux Arts, during college course, and third medal in archaeology, second medal in class A, Beaux Arts, in 1916; student assistant, Carnegie institute of technology, 1914-15; and since Jan. 1, 1916, with Ingham & Boyd, architects, Pittsburgh, Pa.

James Henry Chillman, Jr., as instructor in architectural design. Graduated from the University of Pennsylvania in 1913 with the degree of Bachelor of Science and received the degree of Master of Science in 1914; alumni fellow in architecture 1913-14; three years' architectural practice; since 1914 assistant and instructor of freehand drawing at the University of Pennsylvania.

### Department of Ceramic Engineering.

Edward Wight Washburn as professor of ceramic chemistry and head of the department of ceramic engineering. Graduated from the Massachusetts Institute of Technology in 1915 with the degree of Bachelor of Science and received the degree of Doctor of Philosophy in 1908; associated with the department of chemistry of the University of Illinois for the past eight years in physical chemistry; and has made many noteworthy contributions to science.

Cullen Warner Parmelee as professor of ceramic engineering. Graduated from Rutgers college in 1896 with the degree of Bachelor of Science; honor student in chemistry, associated with Rutgers college in chemistry and ceramics since 1901, and for the past ten years professor of ceramics and director of department of ceramics; sustained important consulting relations with various potteries; contributed extensively to recent literature; member of Phi Beta Kappa and past president of the American Ceramic society.

Howard Clinton Arnold as instructor in ceramic engineering. Graduated from the University of Illinois in 1914 with the degree of Bachelor of Science and received the degree of Master of Arts from Ohio State University in 1916; recipient of preliminary and special honors; since 1914 secretary of the Ceramic Supply and Construction Company, Columbus, O.

### Department of Mechanical Engineering.

Elisa Noel Fales as assistant professor of aeronautics. Graduated from Harvard university in 1908 with the degree of Bachelor of Arts and from the Massachusetts Institute of Technology in 1911 with the degree of Bechelor of Science; organized the Jiffy Duplicator Co., Chicago, Ill.; has had varied experience as a consulting engineer; and since 1915 has been assistant engineer of the Curtiss Aeroplane Co., Buffalo, N. Y.

### Engineering and Mechanics.

Harald Malcolm Westergaard as instructor in theoretical and applied mechanics. Graduated from the Royal college of engineering of Copenhagen, Denmark, in 1911, with the degree of Bachelor of Science; studied at the University of Gottingen and in Technische Hochschule of Munich, Germany, for a year, and for the past two years has been a student in the Graduate school of the University of Illinois, receiving the degree of Doctor of Philosophy in 1916; fellow of the American Scandinavian foundation, 1914-15; member of Sigma XI; designer and assistant on engineering work in Copenhagen, Hamburg and London from 1911-14.

Frank Erwin Richart as instructor in theoretical and applied mechanics. Graduated from the University of Illinois in 1914 with the degree of Bachelor of Science; held a Graduate school scholarship 1914-15, and received the degree of Master of Science in 1915; engineer for the C. F. Massey Co., Chicago, Ill., 1915-16; and since May, 1916, engineer of the Concrete Steel Products Co., Chicago, Ill.

Solomon Cady Hollister as instructor in theoretical and applied mechanics. Graduated from the University of Wisconsin in 1916 with the degree of Bachelor of Science, assistant instructor in descriptive geometry and instructor in mechanical drawing at the State college of Washington while a student at that institution from 1909-11 and 1913-14; since graduation has been with the McClintock-Marshall Co., bridge manufacturers, Pittsburgh, Pa.

### Department of Physics.

Walter Andrew Shewart as assistant in physics. Graduated from the University of Illinois in 1913 with the degree of Bachelor of Arts and received the degree of Master of Arts in 1914; assistant in physics at the University of California 1914-15; and Whiting fellow in physics at the University of California 1915-16.

Harry Tyler Booth as assistant in physics. Graduated from Carleton college in 1915 with the degree of Bachelor of Science and received the degree of Master of Science from the University of Illinois in 1916; assistant in physics at Carleton college 1914-15; Graduate school scholar in physics at the University of Illinois 1915-16; and assistant in the summer session of 1916.

Carl Eli Pike as part-time assistant in physics. Graduated from Cornell college in 1916 with the degree of Bachelor of Science; taught school for two years before entering college.

Roy Andrew Nelson as part-time assistant in physics. Graduated from Knox college in 1916 with the degree of Bachelor of Science; recipient of general honors and special honors in physics 1914-15; laboratory assistant in physics at Knox college 1914-16.

### Engineering Experiment Station.

Walter Arthur Gatward as research assistant in the department of electrical engineering. Graduated from Washington State college in 1913 with the degree of Bachelor of Science and received the degree of Master of Science from the University of Illinois in 1916; won high honor at Washington State college; employed in the operating and engineering department of the Washington Water Power Co., Spokane, Wash., 1913-14; research fellow in the engineering experiment station of the University of Illinois, department of electrical engineering, 1914-16.

Ernest Edward Charlton as research fellow in the department of chemistry. Graduated from Grinnell college in 1913 with the degree of Bachelor of Arts and received the degree of Master of Science from the University of Illinois in 1915; graduate assistant in chemistry at the University of Illinois 1913-14 and assistant in chemistry 1914-16.

Ray Stuart Quick as research fellow in the department of electrical engineering. Graduated from the University of Cailfornia in 1916 with the degree of Bachelor of Science.

Bernard Pepinsky as research fellow in the department of theoretical and applied mechanics. Graduated from the co-operative course at the University of Cincinnati in 1916 with the degree of Civil Engineer; has had five years' practical experience.

Edward Alexander Roberts as research fellow in the department of railway engineering. Graduated from Harvard university in 1914 with the degree of Bachelor of Science cum laude in engineering sciences; and from 1914-16 has been employed as student engineer with the General Electric Co., Lynn, Mass.

Harold Parsons Vail as research fellow in the department of mechanical engineering. Graduated from Pennsylvania State college in 1916 with the degree of Bachelor of Science; has had practical experience in several machine shops and as draftsman for the Ball Engine Co. of Erie, Pa., and the mechanical division of the Panama Canal.

## OBITUARY.

Mr. John V. Beekman, for many years connected with the Lidgerwood Manufacturing Co., died Sept. 11 at his home at Plainfield, N. J. Mr. Beekman was born in 1842 at Somerville, N. J. About 1870 he engaged in the manufacture of rotary engines, pumps, etc., being a member of the firm of John A. Lighthall-Beekman & Co., with works at Imlay St., Brooklyn, N. Y. This company was absorbed by the Lidgerwood Manufacturing Co. in 1873, Mr. Beekman assuming charge of the works of that company, and was the inventor of many improvements in hoisting engine designs. Mr. Beekman gradually withdrew from active participation in business about ten years ago, devoting his later years to outdoor pleasures, becoming an enthusiastic motorist and golfer, being a member of several golf clubs, and a familiar figure on the golf course at Pinehurst, N. C., where he spent his winters. For many years Mr. Beekman had been a member of the American Society of Mechanical Engineers. Mr. Beekman's death is keenly felt by his surviving family, and by the men with whom he was formerly associated.

## INDUSTRIAL NOTES.

A. H. Brown has joined the staff of H. Kleinhaus Co., Oliver Bldg., Pittsburgh, Pa., dealer in railroad and contractors' equipment.

A consolidation has been effected between the Lyons Boiler Works, De Pere, Wis., and the Joliet Bridge & Iron Co., Joliet, Ill. A new corporation, headed by President Andrew W. Woodman of the Joliet company, will be formed to operate the plant.

Buildings and Structural Issue
of

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., SEPTEMBER 27, 1916. Number 13.

## WHAT LESSON DOES THE SECOND QUEBEC BRIDGE DISASTER TEACH?

When the first Quebec Bridge fell during its construction 9 years ago, an engineering journal said that it taught "a lesson in humility." We took issue with that opinion and editorially said:

> The real lesson to be learned from this Quebec disaster is not so much "a lesson in humility" as a lesson in courage in defending individual judgment in the face of any man's opinion, no matter how eminent he may be. Had certain engineers and employes on the Quebec bridge had the courage to fight for their judgment as to the weakness of the bridge, instead of permitting a great engineering reputation to silence them, there would have been no Quebec disaster.

We have had no reason to change our opinion as to the lesson that the first Quebec bridge failure should teach. Now that a second failure of a wholly different kind has occurred, every structural engineer is asking what lesson it teaches.

While the suspended span 640 ft. long and weighing 4,740 tons was being raised from scows to its destined resting place on the main cantilever arms, something gave way and it fell to its "last long resting place" at the bottom of the St. Lawrence. A photograph taken at the instant of failure shows one corner of the span already under water while the other three corners still rest on the supports by which the span was being jacked up. Spectators state that a cannon-like report preceded the failure, indicating quite certainly that some large member of the bridge or its temporary supports failed. Evidence points to the breaking of one of the cast steel "rockers" upon which the span temporarily rested.

The "rockers" were so arranged as to form a universal joint, made of steel castings resting on two large steel pins, one at right angles to the other. The bearings and pins were polished and lubricated, the object being to insure that the friction would not exceed 10 per cent of the load as the surfaces slipped under the end thrust of the suspended span.

It is stated that these universal joints were tested under the full load before the span was towed to position on scows. However, a test under the quiescent load and at constant temperature is not equivalent to such a test as occurred in raising the bridge.

Not only are the stresses developed in a bearing plate through a pin connection somewhat indeterminate, but a greater degree of uncertainty is introduced through the unknown coefficient of friction between the bearing and the pin. What is the coefficient of friction between smooth lubricated steel surfaces under a load of 10,000 lb. per square inch? We doubt whether there are any tests in existence relative to pin and bearing friction at so high a unit pressure as this. Tests of journal friction even up to 1,000 lb. per square inch are by no means numerous. They serve to indicate, however, that the coefficient of starting or initial friction is not a constant, but increases as the unit pressure increases. For example, Thurston's tests on journals lubricated with sperm show starting coefficients of friction as follows:

| Lb. pressure per sq. in. | Co-efficient of friction. |
|---|---|
| 50 | 7% |
| 500 | 15% |
| 1,000 | 18% |

Evidently at 10,000 lb., or even at 5,000 lb. per square inch, the coefficient of starting friction would be much greater than at 1,000 lb. per square inch. As a matter of fact the pressure on one of the bearing pins in the universal joint used in erecting the suspended span of the Quebec bridge was greatly in excess of 12,000 lb. per square inch and probably about 24,000 lb. per square inch! There are no printed frictional tests of lubricated journals or pins at such high pressures, so that we are really in the dark as to the actual coefficient of friction in the universal joint under discussion. We may be quite certain that it was above the 10 per cent assumed by the engineers in their calculations, for the evidence of tests points to higher coefficients of starting friction at higher unit pressures. Some of Thurston's tests indicate that the friction increases as the cube root of the unit pressure.

Let us estimate the unit pressure on the longitudinal pin of the universal rocker joint. The pin was 9½ in. diameter by 46½ in. long, thus giving a projected area of 442 sq. in. Upon this pin the load was about 2,370,000 lb. or more than 5,360 lb. per square inch of projected area. But it is generally assumed that practically the entire load is carried upon one-sixth the circumference of a pin, in which case the unit pressure would have been 11,720 lb. per square inch. Where, we repeat, are the test data relating to journal or pin friction under any such high loading as this?

A thrust of 300,000 lb. on the universal joint, due to temperature changes, was provided for under the assumption of a 10 per cent coefficient of friction. But for aught any engineer knows the coefficient may have been 20 per cent, resulting in a 600,000-lb. thrust, and possibly it may have been much more.

The suspended span had been lifted about 10 ft. in two hours when suddenly there came a loud report, followed by the kicking out of the support from under one end of one truss. The photograph above mentioned shows this kick back very clearly. Then the bridge fell.

Note particularly that the failure occurred when the jacking up process had temporarily ceased. There was no noticeable change in the wind. This seems to leave but one form of variable energy at work, namely, heat. A few degrees drop in the temperature of the bridge would produce great stress in the suspended span, provided it could neither slide on the pins of the universal joints nor swing inward upon the hanger chains that supported its ends. Inward swinging was impossible because of mooring lines. Hence with a higher coefficient of friction than the 10 per cent assumed by the engineers, a correspondingly higher temperature stress would develop. Apparently this occurred and the weakest part of the supporting member—one of the cast steel "rockers"—gave way on the side nearest the center of the river. The truss end then crashed down upon the supporting girder beneath, and striking it off center, tilted it so that it kicked back from under the end of the truss and let the truss fall.

It seems to us that the primary lesson taught by this disaster is this: Engineers should never apply test data much beyond the limits of actual tests unless exceptionally large factors of safety are used. There is grave danger in reasoning that because a 10 per cent coefficient of friction has been shown by test to exist under a load of, say, 1,000 lb. per square inch, the same coefficient will exist under a load of 10,000 lb. per square inch.

The secondary lesson of this disaster seems to be:

Never put your entire trust in a single casting of any sort where its failure spells disaster.

The internal stresses developed in a casting during cooling are large, and largely unknown. Aside from imperfections in a casting itself, there is the ever-present uncertainty as to the shrinkage stresses within it. Particularly is this true of castings not uniform in cross-section, such as these "rocker" castings were. Had the "rockers" been built up of steel plates, the failure probably would not have occurred. If tests of the coefficient of journal friction up to loads of 25,000 lb. per square inch had been made, there would probably have been found a much higher coefficient than the 10 per cent used in the calculations, and accordingly the design of the universal rocker's joint would have been radically changed.

Curiously enough the salient lesson from this bridge failure is akin to the lesson from the Austin (Texas) dam failure. We have pointed out that the coefficient of friction between strata of rock is entirely unknown where unit pressures are large. Consequently we have repeatedly urged the importance of making frictional tests of rock on rock, and on the different kinds of earths, under the large pressures that so often occur in dam practice. We renew our insistance that data as to starting friction under heavy unit loads are so meager as to be inconclusive at best. Since test data of frictional resistance under great unit loads have not been available, engineers have habitually used test data based on smaller unit loads. This is not logical, but it apparently takes more than one great disaster to teach us the needed lesson. Fifteen years have elapsed since the Austin dam went out, and the engineering world is still as ignorant as ever about coefficients of friction of stones and earths under great unit pressures. Our theories of applied mechanics may be ever so perfect, yet they will not save us from disasters unless we have adequate test data. In spite of all the tests that have been made relative to friction, we still have a vast deal to learn about frictional coefficients.

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## JOIN THE STRUCTURAL ENGINEERS' ASSOCIATION OF ILLINOIS.

Since we began advocating the formation of an American Society of Structural Engineers our attention has been called to the fact that there is at least one state in which there is a local society of structural engineers, namely, Illinois.

A year ago (July 5, 1915) civil engineers in Illinois secured the passage of the "Structural Engineers' License Law" under the provisions of which licensed structural engineers are exempt from the provisions of the 1897 act licensing architects. In our next Building and Structural monthly issue, Oct. 25, we plan to publish the "Structural Engineers' License Law" in full, as a model to be followed by engineers in other states seeking relief from the unjust restrictions imposed upon engineers by license laws drawn solely in the interests of architects.

At present we wish to call the attention of structural engineers in Illinois to the local society which, in the best interests of their profession, they should join. This young society is destined to become large and powerful. The sooner it does attain a large membership, the sooner will it be able to bring structural engineers abreast of architects in securing commissions for buildings.

The building field, as we pointed out in our last Structural Issue, is almost unlimited in extent and it offers perhaps the most inviting territory for civil engineering invasion. The editor, while in Pittsburgh recently, came upon some of the work of a firm of engineers and architects whose business has grown to very large proportions. The head of the firm is a structural engineer and his partner is an architect. The pronounced and rapid success of a partnership of this character certainly merits the consideration of every structural engineer who contemplates securing an independent professional practice in the building field.

But whether a structural engineer plans to be the head of a firm of building designers or not, he should become an active and enthusiastic member of a structural engineering society. Such a society can promote the interests of all structural engineers, whatever their position. This is the era of joint action for a common purpose. Don't be one of the "let George do it" men. Join your fellow structural engineers and stay joined.

If you are an Illinois structural engineer write now to Mr. R. M. Gerety, secretary Structural Engineers' Association of Illinois, suite 1015, 30 North La Salle St., Chicago, and ask for information about the society.

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## WHY NEW YORK ENGINEERS SHOULD "PLAY POLITICS."

The "head of the ticket" is the governor and the "tail of the ticket" is the state engineer and surveyor in New York state. This is so not only as to position on the ballot but as to salary, yet the position of state engineer is scarcely second in importance to that of governor.

Surely the time has come when engineers in New York state should take joint action to give to the position of state engineer the standing in the public eye that is merited by its importance. The first step toward this goal should be the raising of the salary from $5,000 to $10,000. The next step should be the selection of candidates for this engineering position by engineers themselves. It would not be difficult to get all political parties to accept the recommendation of a large organization of engineers as to the qualifications of aspirants to the state engineership.

A word here as to the salaries of all engineers in the employ of New York state. If we are not mistaken the salaries are today no higher than they were 25 years ago. No legislature would be likely to resist the appeal of an organized body of civil engineers for a moderate increase in salaries that were established by statute 25 or even 10 years ago.

New York engineers should not only bring up these matters for action at the next legislative session, but they should secure the passage of a law giving licensed structural engineers equal rights with licensed architects. The attorney general of New York has ruled that engineers, or in fact anyone, may practice architecture in New York state, but shall not use the term "registered architect." Here, as in most states, the standing of a structural engineer is purposely made subordinate to that of an architect where building design is involved.

These are by no means the only things about New York statutes that need radical re-engineering, but we suggest them as good places to start an engineering-political campaign.

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## UNIQUE BRIDGE ERECTION.

The method by which the suspended span of the Quebec Bridge was being erected when the accident now familiar to the engineering world occurred is described in another column. This description, it is perhaps proper to say now, was written prior to the date of erection and to the accident. The lessons of the accident are discussed in another editorial. Here we propose to remark only on the plan of erection, which was unique in bridge engineering practice.

In previous cantilever bridge erection, or at least in previous erection of cantilever bridges of major size and high above the water, the practice has been to erect the suspended span piecemeal as extensions of the cantilever arms. Until final connection and adjustment were completed at mid-span the suspended span trusses acted as cantilevers; after final connection and adjustment the suspended span trusses became simple trusses seated on the projecting ends of the cantilever arms. The safety and surety of this traditional erection practice is unquestioned in so far as safety and surety are ever certain in bridge construction of great magnitude. The method, however, has its objections. It calls for truss design which is abnormal, so far as simple truss stress requirements are concerned, in order to provide for erection stresses. It also prolongs the erection period, for no erection work on the suspended span is possible until the cantilever arms are completely in place.

At Quebec the elimination of these objections and the gain of other advantages were sought by a plan for erecting the suspended span as a completed unit. A span of 640 ft. containing upward of 4,740 tons of steel requires time to erect. By erecting it separately from the remainder of the bridge the work could proceed simultaneously with the erection of the remainder of the bridge and when this main task was completed the placing of the separately erected span completed the bridge in a few hours compared with the time required to construct it member by member in place. The plan was sound in theory and the methods devised for carrying it out were simple and ingenious. That failure in erection occurred seems at first sight to condemn this plan. The layman certainly and many engineers probably will visualize only the failure. A more analytical judgment than this is warranted by the facts.

## EDITORIAL COMMENT.

A bridge 5.5 miles long and costing $22,000,000 is planned to be built by San Francisco across the bay to Oakland. It will be a double-decker, carrying four railway tracks and three roadways. This will be the most costly bridge in the world.

It is said that low carbon steel alloyed with 12 per cent chromium produces a rustless alloy. Thus far its principal use has been for cutlery, but may it not ultimately find application in thin sections of structural steel?

Will light colored walls reduce the expense of illuminating office buildings 30 per cent? At the recent convention of the Illuminating Engineers' Society, Mr. Samuel G. Hibben, of the Westinghouse Electric and Mfg. Co., read a paper on "The Economics of Office Building Lighting," and, among other valuable pieces of information, gave test data showing that the annual cost of illuminating a moderate sized office building can be cut from $15,000 down to $10,000, merely by the use of light-colored interior painting.

When it is known that nearly all the heat that escapes from a building by conduction and radiation passes through the glass windows, one wonders why every window sash is not made with two plates of glass and an air space between. If any one will estimate the return on the investment in the added plate of glass, as a result of the coal saved, he will get a result that will make "100 per cent Miller" look like a "piker."

The engineer as a designer of buildings will at least give adequate study to the problems of heating, ventilation and illumination. Consider the average dwelling, which is so often pleasing to look at but irritating to live in, and then ask why its designers ran to the appearances and forgot the utilities.

It has been disputed whether surveying first came into existence as a nautical science or as a land science—a wet or a dry science. The magnetic compass made navigation scientific. Prior to the compass there was little that might be called a science of surveying. It seems likely, therefore, that the first surveyors to use angle measuring instruments were the navigators.

When the history of earth and rock moving comes to be written the "Dinky" (locomotive) is certain to have a prominent place in the narrative. We wonder whether many excavating contractors have stopped to think to what an extent the industrial locomotive, that miniature brother of the Dinky, is usurping the place of the older machine. The industrial railway (locomotive, cars and portable truck) has become almost as familiar on construction work as around the factory.

## CONCRETE FOR SALE.

To the Editor: Your editorial, "Concrete for Sale," recalls some of the difficulties I encountered in this direction some years ago, when as a young and ambitious engineering student I saw great possibilities of fame and fortune awaiting me in the sale of ready-mixed aggregate.

I got my original ideas from a paper by Wm. B. Fuller, an authority on concrete. Mr. Fuller recounted how he had secured absolute impermeability, greater density, and great economy of cement, without sacrificing strength, by the use of aggregates of several sizes, ranging from sand through the smaller sizes gravel up to the largest practical size of stone, 2½ in. These aggregates were proportioned according to a parabola, with the smaller sizes at the apex, the ordnates representng proportions and the abscissas representing sizes.

My plan was to mix aggregates in these scientific proportions and sell direct from the gravel pit or crusher, so that all the contractor would have to do would be to add cement and water.

The practical difficulties which arose were these: Mr. Fuller advised me that unless each batch was kept by itself the aggregates would separate and require mixing, which would defeat the purpose of the original mixing, and involve the use of as much cement as with ordinary concrete; secondly, the difficulty of getting the consent of the architects and building departments for the use of less than the usual amount of cement was insurmountable, and without this consent I could offer no great inducement for my aggregate, except that it would not have to be mixed as much as sand and stone bought separately; then, finally, there was the difficulty of persuading the contractor that he would be getting as much for his money as before, as the contractor in most cases could not appreciate that a load of sand mixed with two loads of stone does not make three loads of mixed aggregate.

These reflections from the failure of one of my first inspirations prompt me to suggest that the same difficulties will be met, with many more due to the cement factor in the equation, in the marketing of ready-made concrete.

One of these added difficulties, which I think you have overlooked, is the unreliability of delivery, and the chance of the job being held up by the breakdown of trucks or central plant. As engineer in charge of materials on a big construction job in Jersey City several years ago, I had a hard enough time to get sand and gravel on the job to keep the mixer going, even when I had a day or two start of the mixing gang. Imagine my troubles if I had had to co-ordinate the delivery of material precisely with its use.

But there is one unanswerable argument in the scheme's favor: it is right now being used on the New York city subways, and apparently with the greatest success. Here's good luck to anyone with the courage to risk his hard earned money in the pioneering.

John C. Crozier.

Milburn, N. Y., Aug. 25, 1916.

## STRENGTH OF CLAMPED SPLICES IN CONCRETE REINFORCEMENT BARS.

To the Editor: The writer believes that the paper by E. L. Lasier, entitled, "The Strength of Clamped Splices in Concrete Reinforcement Bars," presented at the recent annual meeting of the American Society for Testing Materials, has not been properly commented on by engineers. He has been strengthened in this belief by the appearance of an advertisement of a firm which manufactures bar splices.

The author of the paper states "That clamped lap splices embedded in large masses of concrete undoubtedly can safely withstand a unit load equal to the unit stresses in steel reinforcement." The manufacturers quote the above statement and we may see in the near future a large number of contractors and engineers using spliced reinforcement. For large bars it is stated that the cost of the splices and labor will be less than the cost of the additional length of bar required for bond.

The author's experiments plainly show that the ratios of load at first slip to yield point of bar for clamp splices embedded in concrete varied from 53 to 83 per cent. We know from experiments that by using embedment of proper length for bond 100 per cent efficiency can be secured. Assuming the yield point of the steel to be 32,000 lb. per square inch, and a fiber stress of 16,000 lb. per square inch is used in designing, the steel when lapped can be depended upon to hold in the concrete until the elastic limit is reached, thus giving a factor of safety of two, based on the elastic limit.

It is poor engineering to use a form of splice in which the ratio of slip to the elastic limit varies from 53 to 83 per cent when 100 per cent can be obtained by methods universally approved.

We are to assume that in the laboratory tests the greatest care was used, yet splices cannot be depended upon to safely withstand a unit load greater than the allowable unit stress in the steel reinforcement bars, consequently there is no factor of safety. It is not reasonable to assume that all splices in the field will be better than the bar splices made in the laboratory, and a warning should be issued against the use of clamped splices for reinforcing bars.

The writer noticed in several cases that bars were spliced by welding. In concrete arch bridges where the unit stress in the reinforcement is very low there may be no danger in welding the main reinforcing bars. In beams and girders in which the steel will be stressed to 16,000 pounds or more per square inch, the splicing of bars by welding is a dangerous practice.

The writer hopes you will publish this letter and also comment editorially in a forcible manner on the subject matter. If this is not done there may be many failures.

Yours truly,
Ernest McCullough, Consulting Engineer.
Chicago, Ill., Aug. 23, 1916.

## A COST KEEPING SYSTEM FOR BUILDING CONTRACTORS.

Contributed by D. B. Duncan, Springfield, Mo.

The forms will serve to illustrate an estimating, bookkeeping and cost keeping system designed to meet the requirements of a firm of general contractors engaged in building construction. The system, in so far as possible, avoids bookkeeping and clerical work on the job. All of this work being handled in the main or a branch office.

All record sheets, with the exception of the small time cards, have been made the size of letter heads to facilitate filing in office; for this reason also some of the sheets are printed on paper of different colors.

The estimating sheet will be readily understood. The information shown on outside page of this estimating sheet serves simply as a matter of record and to recall to estimators' minds the main facts about the building in case of future reference. The estimating will be done in sheets the same size as letter head and after completing these computations, a similar sheet will be made showing all information contained in the estimate. These computation sheets will then be fastened together and covered with a paper cover ready for file.

ESTIMATE SHEET
L. W. DUMAS, Jr., CONSTRUCTION CO.
Columbia, Mo.
*Character of Building*..................*Location*..........................
*Owner*..............................*Architect*..........................
*Bid Placed*.............*Cubical Contents*............*Cost per cu. ft.*..........
*Work Let for* .........................*Date Letting*......................
*Items Reserved by Owner* .......... ........................................
*General description of building:* .......... .......... ........................

(Outside Page)

Blank for Estimate Sheet.

The small time cards, B and C, are the field daily records of labor and material used on the work. They are to be kept by the timekeeper, who, at the end of each week will assemble the information and fill out the field superintendent's report sheets. After checking, these sheets will be forwarded to main office by the superintendent. The interval of time between the end of week and pay day will be sufficient to allow the checks to be made out in the main office and returned to the superintendent.

L. W. DUMAS, Jr. CONSTRUCTION CO.
Columbia, Missouri
FIELD SUPERINTENDENT'S REPORT.
Building..................Location..............Week Ending..............
Labor DISTRIBUTION SHEET

| Distribution | Paid for Labor | Amount of Work | Unit Cost of Labor |
|---|---|---|---|
| | | | |
| | | | |

Material

| Distribution | Material Used | Work Done | Unit Quantity |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

Distribution Sheet for Labor and Material.

The superintendent will have one copy of these weekly records, which he will retain on work. The original sent to the main office will be filed there and not be returned for use in paying off men. The column in payroll sheet headed "Money Advanced" is to be used to record amounts paid for labor between pay days. For this purpose a small amount of money will be sent to the superintendent and charged to him. He will pay these bills either in cash or by personal check. At the end of each week the total amount of the money advanced will be credited to the superintendent's account. It is the duty of the superintendent to see that the material records are accurately kept by timekeeper, as all of the unit must depend on this information.

L. W. DUMAS, Jr., CONSTRUCTION CO.
Columbia, Missouri
FIELD SUPERINTENDENT'S REPORT
Building................ .Location..................Week Ending........
PAYROLL SHEET

| | Name | Remarks | Kind of Labor | Hours Worked | Rate | Total Am't | Money Advanced |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |

Payroll Sheet.

L. W. DUMAS, Jr. CONSTRUCTION CO.
Job.......................... Location.....................
Material Sheet

| Day | Material Used | Work Done |
|---|---|---|
| Mon. | | |
| Tues. | | |
| Wed. | | |
| Thur. | | |
| Fri. | | |
| Sat. | | |
| Sun. | | |

Material Sheet.

In the main office will be kept journal record and a looseleaf general ledger. Also a looseleaf ledger for each job in course of construction. These ledgers will be of the same size as the other report sheets. The office ledger will be items of overhead expense, account with bank, etc. Invoice, etc., paid, will be entered on journal and distributed to proper ledger. Information coming in on field superintendent's report will be copied directly in job ledgers to which they belong.

The job ledgers will have on first sheet the general information regarding the job in question and will be a copy of the information given on outside of the estimate sheet. It is put in the job ledger for handy reference. The second page of ledger will have an exact copy of the detailed estimate; after this will be the index to ledger. The sheets of the ledger will be ruled on both sides; one side will carry the same heading as that item is listed on the estimate sheet and will be ruled as single entry ledger or similar ruling. The other side of this same sheet will be ruled as a double entry ledger and will be used to carry the account of the sub-contractor to whom the work shown on the other side of sheet has been let. This page will, of course, not be used if the work is carried on by the day by the general contractor.

L. W. DUMAS, Jr. CONSTRUCTION CO.
Job.............................. Location..............................
Name..............................
Occupation..............................

| Day | Distribution | Time | Money Advanced |
|---|---|---|---|
| Mon. | ............................................ | | |
| Tues. | ............................................ | | |
| Wed. | ............................................ | | |
| Thur. | ............................................ | | |
| Fri. | ............................................ | | |
| Sat. | ............................................ | | |
| Sun. | ............................................ | | |

Week Ending..............................19......
Total Time (Hrs)................Rate................Total..............
Amount of Check....................
Money Advanced....................

Daily Field Labor Sheet.

| Page Spec. | Character Work | Remarks | Qauntities | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

(Inside Page)

Estimate Sheet.

The detailed records of the unit costs of the work and the amounts of material will be kept in the same ledgers and carried in the back of ledger. These pages will be ruled to suit the conditions.

After the completion of any contract a summary of all the cost data contained in the job ledger will be made up and filed in a cost record file; also a copy will be filed in with each ledger. The ledger, computations, estimates, correspondence, etc., will now be filed. These may be all filed together, as they are the same size, or they may be filed separately, as desired.

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The final contract for the construction of the 4th Ave. Rapid Transit R. R. in New York City, was awarded last week to the Degum Contracting Co., 30 East 42d St., New York City, at $10,265. The section lies in part underneath the Atlantic Ave. Station of the Long Island R. R. in Brooklyn. The contract was not let until this time owing to the necessity of first completing the preliminary construction by the Long Island R. R. This consisted of a concrete slab for the railroad tracks, which eventually will form the roof of the subway.

## THE NEW GOVERNMENT DRY DOCK AT NORFOLK, VA.

Bids are now being asked by the Bureau of Yards and Docks of the U. S. Navy Department for the construction of a new dry dock at the navy yard, Norfolk, Va. This will be known as Dry Dock No. 4 and will be one of the largest structures of its kind yet undertaken by the government. The general dimensions of the new dry dock will be as follows:

| | |
|---|---|
| Elevation of coping | 100.5 |
| Elevation of mean high water | 95.21 |
| Elevation of top keel and docking keel blocks | 55.9 |
| Elevation of sills | 51.5 |
| Elevation of floor of dock | 49.5 |
| Length over all of dock on center line from outside at head to outside of apron | 1,064.25 |
| Length of dock from inside of coping at head to outer sill | 1,022.0 |
| Width of dock over all at coping level | 212.5 |
| Width in body of dock between copings | 144.0 |
| Width between faces of lowest altars | 110.0 |
| Width of entrance at coping level | 126.98 |
| Width of entrance at level of mean high water | 125.67 |
| Depth from coping level to floor of dock | 51.0 |
| Depth, coping level to sill of dock | 49.0 |
| Depth, mean high water to sill of dock | 43.74 |
| Distance between caisson seat No. 1 and caisson seat No. 2 | 25.0 |
| Distance between caisson seat No. 1 and caisson seat No. 3 | 684.0 |
| Depth mean high water to top of keel block | 40.24 |

The elevations refer to navy yard datum, which is assumed to be 100 ft. below a point in the coping of Dry Dock No. 1 at its inner end.

The side walls, including all supports for tracks, and the floor of the dock will be of concrete. All interior surfaces of the dock will be backed with metal fabric reinforcement as a preventative of surface cracks. The entire structure will be subdivided into an inner dock and an outer dock by an intermediate caisson seat. The floor section of the dock, throughout its entire length, will have two longitudinal drains of varying diameters, symmetrically placed with respect to the center line, having drain connections to the floor of the dock at intervals of 4 ft. A rudder pit will be located near the entrance of the dock and will be provided with steel nosing and terra cotta drain. A cast iron drain connection, with a valve in the rudder pit, is provided from the caisson seat.

The cross culverts between the filling sluice and the longitudinal drains will be cast iron pipes provided with cast iron tees or crosses at points of intersection with longitudinal drains. The floor section also is provided with two longitudinal lines of 8-in. vitrified sewer pipe, having outlets to the floor of the dock at intervals of about 36 ft. Each outlet consists of a 4-in. terra cotta riser, surmounted by a 4-in. cast iron top section. Two suction culverts will be formed in the concrete of the floor section, for the service of Dry Dock No. 3. A 36-in. conduit across the dock will be provided, together with a 12-duct terra cotta sectional, electric conduit, both of which start at the drainage pump chamber and terminate in a manhole on the north side of the dock.

The side walls of the dock, which include the side walls proper and the piers, girders, etc., for support of accessories, will be different cross sections for the two sides of the dock, due to the necessity of providing for a future Dry Dock No. 5. The altar edges, coping steps to pump well, and bollard platform at pump well will be provided with steel nosings. The walls and accessory piers, abutments, etc., will provide the necessary supports for crane rails and for standard-gauge tracks. The pump well and the filling, suction and discharge culverts are in the south wall. An elevator shaft, provided with winding staircase, will be installed on the north side of the dock, with shaft opening to the floor of dock and to the next highest altar. A subsurface live-rail conduit with numerous manholes will be provided, completely around the dock. A 12-duct, sectional, terra-cotta electric conduit will be installed around the dock, at the coping, with numerous manholes providing access thereto. The coping will be provided with a guardrail, extending completely around the dock, consisting of removable stanchions and chains. Manholes and capstan pits will have 3-in. pipe drains with gate valves discharging into dock. Six-inch cast iron fresh-water mains, salt-water mains, and high-pressure air mains will be installed by the government the entire length of both sides of the dock. Numerous 4-in. cast iron branches with valves will be taken off and extended to the face of side walls at coping level; also additional high-pressure air branches will be embedded in the side walls with outlets in side walls of dock at floor level.

The pump well will be provided with operating floor, galleries, ladders and handrails. The roof will consist of removable sections, constructed of structural steel, cast iron frames and reinforced concrete, into which are embedded approved, stock glass lights, the whole being absolutely water-tight. The exterior walls of pump house above the coping will be provided with pivoted metal sash and metal doors. The galleries and operating floors will have checkered steel plates, supported on structural steel framework. The galleries will form steady-bearing supports for shafts of pumps. All sections of the galleries and operating floor in the four main pump chambers will be removable, but only certain sections in the adjacent chambers will be removable. An independent cast iron discharge main is required from the drainage-pump chamber to the entrance of the dock and overboard; also cast iron drainage mains for the service of the several chambers in the pump well, discharging to the sump.

The suction culverts are arranged to accomplish the following results: Empty inner dock. Empty outer dock. Empty Dry Dock No. 3. Empty Dry Dock No. 5, when installed.

Sluice gates are provided for the first three operations only. The suction culverts for the service of Dry Dock No. 3 pass across the contemplated dock and are carried beyond to the pump well of Dry Dock No. 3 and are connected thereto. The projected future openings to Dry Dock No. 5 will be completely filled with concrete, but cleavage joints coated with pitch and having two water stops are required to facilitate the removal of this filling for the future installation of sluice gates and culverts for the service of a future dock. The filling culvert, with sluice gates, is designed to fill either the inner or the outer dock, or both, simultaneously. The suction culvert from the inner dock acts also as a filling sluice for this portion of the dock. The discharge culvert runs from the pump well to the face of the dock, where it discharges. This culvert also furnishes ingress for the water supply to the filling sluices. All sluice gates that take pressure on both sides will be cast into the concrete and provided with water stops. Chambers above water compartments are to be made water-tight by gaskets and plates, or by some other approved method to prevent the entrance of water through the vertical openings designed for the removal of the gates, or for other purposes.

The sluice gates will be hydraulically operated and will be of the following sizes:

Two gates, 8x8-ft. openings, suitable for a maximum head on either side of 67 ft., for the suction from Dry Dock No. 3; three gates, 8x8-ft. openings, suitable for a maximum head on either side of 60 ft., for the suction to the new dock; five gates, 7x9-ft. openings, suitable for a maximum head on one side of 44 ft., for filling sluices. The gate frame, plug and guides will be made of the best quality of semi-steel, composed of selected new pig iron and mild steel. The gates will be opened and closed by means of a double acting piston, working inside of a cast iron or cast steel cylinder, actuated by oil under a pressure of 300 lbs. per sq. in.

The concrete for the body of the dock and for the capstan foundations will be 1:2½:5 mix. A certain quantity of the above-mentioned concrete will be waterproofed for installation in the following locations: Upper surface of the floor of the dock to a depth of 3 ft.; the inner faces of side walls to a depth of approximately 3 ft., all capstan pits, and electric manhole, and certain walls and floors separating dry compartments from wet compartments or from compartments which may become wet through percolation. Waterproofing will be prepared by the integral method, combining with the cement a weight of Toxement equal to 2 per cent of the weight of the cement, the mixing to be done at the mill.

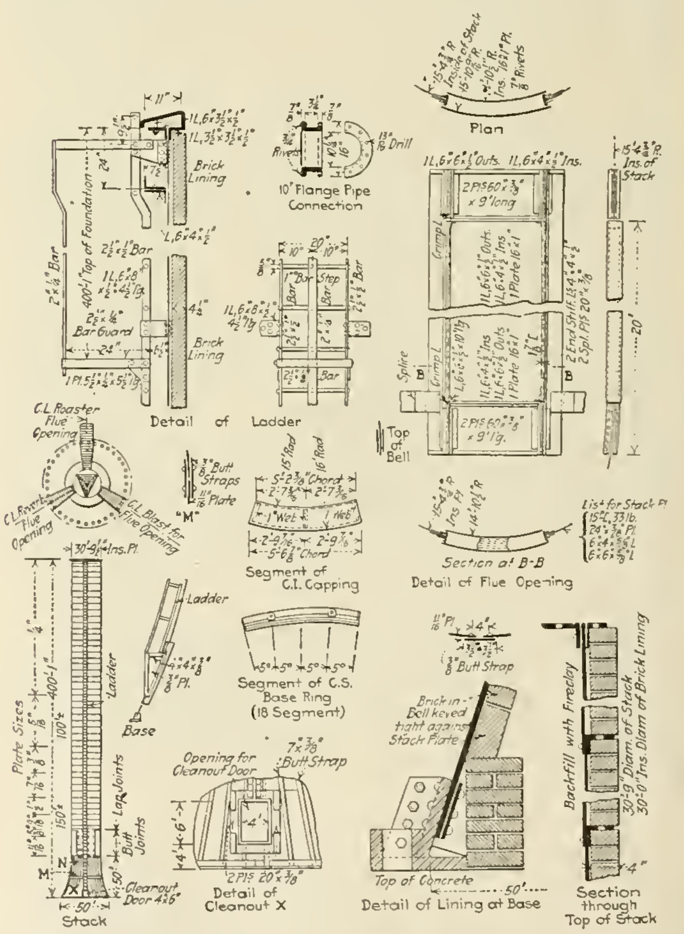
Concrete mixed in the proportions of 1:2:4 will be used for the following parts of the work: Crane-track girders and slab. Bollard and hand capstan foundations. Roof of pump well and sluice chambers. The contractor may embed in the concrete of the floor and side walls of the dock blocks of sound, hard rock not exceeding in the largest dimension of the block one-third the minimum thickness of the concrete body where it is embedded and in no case exceeding 3 tons in weight or 6 ft. in any dimension.

The approximate quantities include the following:

| | |
|---|---|
| Cofferdam and pumping. | |
| Excavation, neat side lines of dock to 3 ft. above bottom, cu. yd. | 489,400 |
| Excavation, below 3 ft. line, cu. yd. | 25,935 |
| Excavation, miscellaneous, cu. yd. | 15,610 |
| Dredging, cu. yd. | 130,000 |
| Concrete, plain, 1:2½:5, body of dock and capstan foundation, cu. yd. | 137,800 |
| Concrete, 1:2½:5, waterproofed, cu. yd. | 31,200 |
| Concrete, 1:2:4, girders, bollard foundation, proof of pump well, sluice chambers, cu. yd. | 7,350 |
| Piling, round, under designed structure, lin. ft. | 12,544 |
| Piling, round, under piled dock, lin. ft. | 277,682 |
| Piling, sheet steel, lb. | 20,000 |
| Granite, caisson seats, abutment coping, discharge culvert face, face of dock, lin. ft. | 21,415 |
| Structural steel, pump well, lb. | 169,650 |
| Structural steel, dock, lb. | 88,100 |
| Galvanized steel, lb. | 198,674 |
| Coated steel, lb. | 108,725 |
| Reinforcing rods in dry dock floor, lb. | 497,900 |
| Reinforcing rods in dry dock walls, lb. | 408,580 |
| Reinforcing rods in pump well, lb. | 22,712 |
| Reinforcing rods in crane track system, lb. | 259,560 |
| Reinforcing rods in culvert. | 110,940 |
| Wire fabric reinforcement, lb. | 107,115 |
| Cast iron pipe, in filling system, lb. | 701,500 |
| Cast iron pipe in pump well, lb. | 54,500 |
| Cast iron pipe, miscellaneous, lb. | 159,900 |
| Cast iron specials, lb. | 224,500 |
| Cast iron miscellaneous, lb. | 459,669 |
| Oak lumber, ft. B. M. | 860,430 |
| Maple lumber, ft. B. M. | 600,468 |

## THE TALLEST STEEL CHIMNEY.

The drawings of the accompanying engraving describe a steel chimney erected at the United Verde Copper Works in Arizona and named by A. G. McGregor in Transactions American Institute of Mining Engineers in August, 1916, the tallest steel chimney ever built. Specifically this chimney is 30 ft. 9½ in. in diameter and 400 ft. 1 in. high. The drawings present all the essential structural features and may be read for details in which the reader is interested.



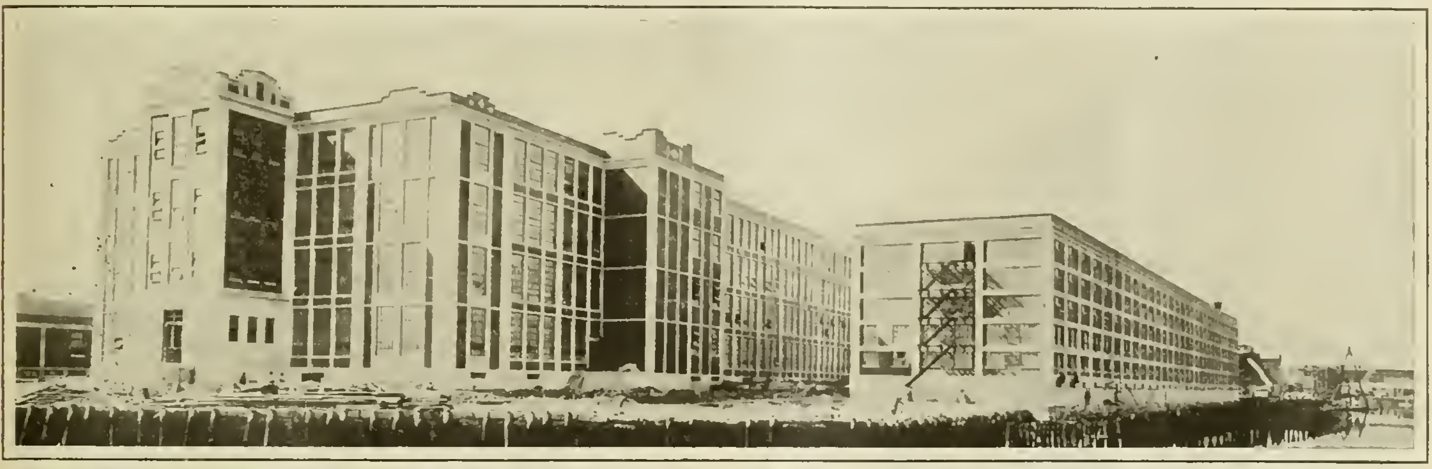
Details of Steel Chimney for United Verde Copper Company.

## NEW PLANT OF THE NAUMKEAG STEAM COTTON CO., AT SALEM, MASS.

Contributed by Lockwood, Greene & Co., Engineers, Boston, Mass.

A new reinforced concrete plant has recently been completed for the Naumkeag Steam Cotton Company, at Salem, Mass., replacing a number of buildings completely destroyed by the great Salem fire of June 25, 1914. The new buildings represent the most advanced standards in mill construction and they have attracted wide attention.

The new plant includes a group of three principal structures, the storehouse, the spinning mill and the weave shed, there being in addition to these a new heating plant. The buildings while designed for their particular uses in the process of textile manufacturing are of unusually pleasing architectural appearance, the use of brick curtain walls in contrast to the concrete giving a very attractive finish.



Plant of Naumkeag Steam Cotton Co., Salem, Mass.

The store house is a building of five stories and a basement, 500 ft. long, 108 ft. wide at one end and 57 ft. wide at the other. The mushroom type of construction is used in this building and there are steel sash throughout, and in addition to storage space this building contains sampling and opening rooms.

The spinning mill, of beam and slab construction, 722 ft. long and 135 ft. wide, consists of four stories and the basement. The column spacing is 26x24 ft. On account of the wide spacing of the columns and the loads that the several floors would have to carry, it was found advisable to change from the regular type of reinforced column to columns with structural steel cores in those that support the 2nd, 3rd and 4th floors. By doing this the diameter of the columns was kept to a minimum, thus saving valuable floor space in the mill.

The floors of the picking and carding departments are finished with a granolithic top, while other departments in this building have a wood top floor. In the floors with wood top the regular concrete slab is poured, on this are laid screeds held down to the concrete by clips which have been imbedded in the concrete, and the space between the screeds filled with cinder concrete. On top of these screeds is laid an intermediate floor; both screeds and intermediate flooring being treated with wood preservative, and the whole finished with a maple top floor.

The roof pitch is obtained by filling in with cinder concrete at the proper depth on top of the roof slab so that the water will drain to the several conductor pipes which pass down through the inside of the building. On top of the cinder concrete is a tar and gravel roof. Steel sash are employed throughout and double glazing on the north and east sides.

The weave shed is 990 ft. long, one portion of it being 420x482 ft. and the other 508x212 ft. The roof of the weave shed is made of beam and slab construction and in order to do away with condensation a layer of cork was placed directly on the slab and on top of this the asphalt and slag roofing is placed.

The skylights are made up of hollow metal sash of double glazing so as to insure against condensation. The ventilators placed at different parts of the roof at the high point of the sawtooth skylights are controlled from dampers from the inside. The floors are finished with a wood top made up in a similar manner to those in the mill. The cloth room is contained in this building.

The hot water heating is supplied from a boiler house of brick and steel, in which in addition to the boilers and pumps for the heating system is located the fire pump room. The chimney is of brick 150 ft. high.

These buildings were designed by Lockwood, Greene & Co., engineers, of Boston, Mass., and erected under their supervision.

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## HEATING MATERIALS FOR BRIDGE PAVING IN COLD WEATHER.

In the construction of the Harrison St. bridge at Fort Wayne, Ind., it was necessary to put down the paving during the winter. We are indebted to C. B. Freeman, chief engineer of the Carmichael-Cryder Co., St. Louis, Mo., the contractors for the bridge, for the following description of the methods used:

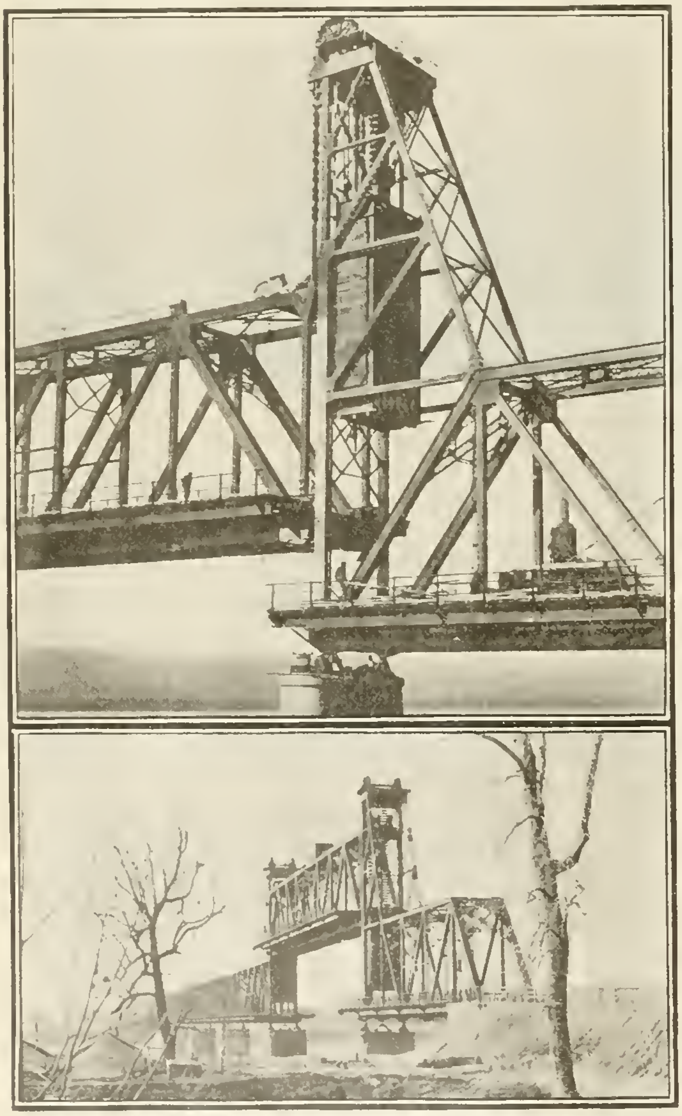
Because of the delay in getting the material to make the fill over the arches, the paving work on the bridge ran into the winter and special precautions had to be taken in order to handle properly the concrete base and pavement. As is customarily done, the sand and gravel were strung out along the roadway behind the large street paving mixer which was used. Steam jets with flexible hose connections were inserted in these material piles at various points and fed from a portable boiler which was kept fired during the night. By confining the heat under large tarpaulins enough material was ready each morning to permit of continuous concreting during the day. The earth fill under the material piles was also in this manner freed from frost. As soon as the concrete was placed, it was covered with a 3 ft. bed of loose straw which effectively prevented freezing. When the pavement was laid, heated sand was wheeled forward and spread out only a very short distance ahead of the pavers.

What promised to be the greatest difficulty was the placing of the asphalt filler in the spaces between the cold bricks in such a way as to insure its going into all of the interstices before it was congealed. This difficulty was gotten around by using a large bitulithic pavement burner. This burner covered an area of about 12 sq. ft. and was simply run back and forth over the bricks ahead of the workers, handling the asphalt filler. The flames in this burner were so hot that it was necessary to be very careful not to crack the paving blocks, but with a little care this was easily avoided and the filler, heated to the maximum degree, was placed very satisfactorily.

## A NOVEL ELECTRICALLY OPERATED LIFT BRIDGE.

Contributed by Frank C. Perkins, Buffalo, N. Y.

The accompanying illustrations show the details of construction of the unique lift bridge over the Arkansas River at Pine Bluff, Ark., as designed at Kansas City, Mo., by Engineers Ira G. Hedrick and Victor H. Cochrane. The electric operating machinery is quite simple as at each corner of the span there are two heavy sprocket chains attached at one end of the top of the tower posts a short distance below the top of the top chords. These operating chains are attached to horizontal links to equalize the stresses and are provided with bolts at top and bottom to adjust the position of the chains and to regulate the tension. At a point a little above the top chord each part of sprocket chains is lopped back towards the center of the lift span in a horizontal direction between two pairs of idler sprockets and then passes over drive sprockets. These sprockets are operated by a train of gears connected to a motor. There are two electric motors, one at each end of the span, each operating the two pairs of driving sprockets at that end of the span. The train of gearing, the drive sprockets, and the idler sprockets at the corner of the span are all attached to a structural steel frame. In order to insure that both ends of the span move together, the mechanism at the two ends is connected by a line shaft. In case an electric motor at one end should get out of order the motor at the other end will operate the span, the line shaft being capable of transmitting sufficient power to the other end. To the line shaft is attached the hand operating capstan near the center of the span.



Views of Lift Bridge at Pine Bluff, Ark.

## THE ERECTION OF THE SUSPENDED SPAN NEW QUEBEC BRIDGE.

Contributed by G. V. Davies and N. C. McMath, Assistant Engineers St. Lawrence Bridge Co., Limited.

There will be four stages in the erection of the suspended span of the new Quebec bridge, as follows: (1) The placing and loading of the scows under the span; (2) towing the span into position under the two cantilever arms; (3) hitching on and lifting by jacks, and (4) the final connections to the cantilever arms.

The suspended span has been erected on steel falsework at Fillery, a village about three miles below the bridge site, on a large flat, which is usually bare at low tide, but with sufficient depth of water at high tide to float the span when the scows are in place.

The span will be floated on six steel framed, timber sheeted scows, each 164 ft. 6 in. long, 32 ft. wide and 11 ft. 7¼ in. deep, with a capacity of approximately 1,000 tons.

The load on each scow is carried by four steel bulkheads, which connect with three longitudinal steel trusses. The scows are placed under the suspended span with their length at right angles with the span, each one located under a floor beam as shown in Fig. 1, the grillage being composed of track girders and stringers built up on the decks of the scows so as to distribute the load on the bulkheads. There are valves in the scows which are kept open until the day of flotation so that the scows will fill and empty with the rise and fall of the tide.

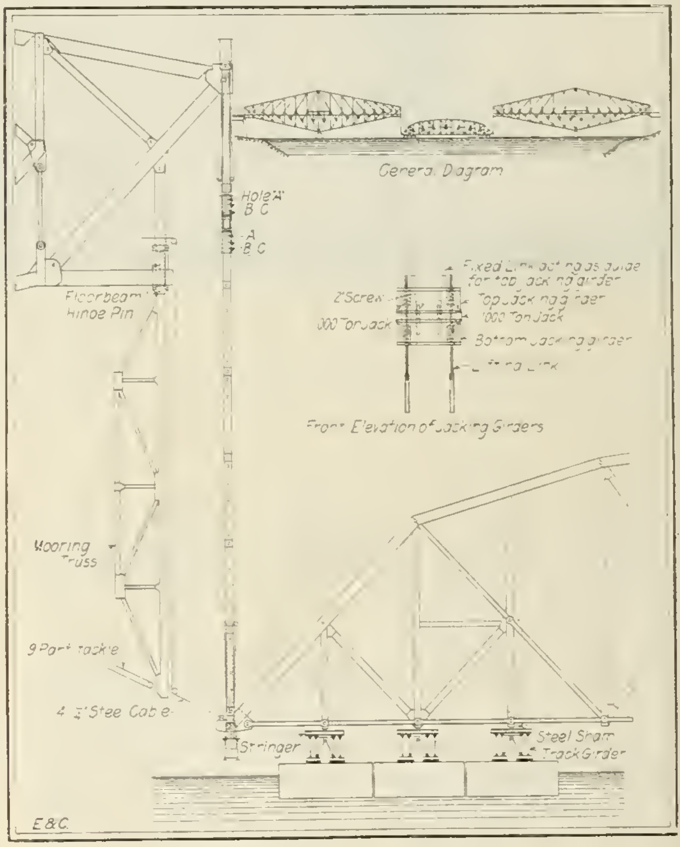


Fig. 1—Sketches Showing Method of Raising Span.

Hanging from No. 1 floorbeam of each cantilever arm is a steel mooring truss, shown in both Figures 1 and 2. This pivots on a pin just under the floorbeam so that the lower end may be raised by block and tackle in case the span is not squarely in the middle of the river when floated down. Mooring lines will be fastened from the base of the truss to the corners of the span so that when the span is in approximate position it can be pulled into almost the exact position required.

Fig. 2 also shows the temporary links which extend from the intersection of the top chord and end post down to the level of the span when afloat. These links are pin connected to the span, the bottom pinhole being slotted approximately five feet for ease in connection.

As shown in Fig. 1, there is a girder setting on a pin on top of each end post. From this girder, which is in a fixed position, hang two lengths of fixed links, to the bottom of which is bolted the lower jacking girder, also in a fixed position. On the latter stand two 1,000-ton hydraulic jacks, having a two-foot stroke, on top of which is the upper jacking girder, sliding on the fixed links. There are also two screws between the girders, which will follow up the jacks when lifting as a safeguard against an accident to the jacks.

Each jacking girder is made up of two plates with vertical diaphragms between. The jacking is against these diaphragms, which also contain the pinholes for the link connections. There are six lengths of these links about 30 ft. long between the top jacking girder and the connection to the suspended span, with pinholes spaced 6 ft. centers. These are shown clearly in Figs. 1 and 2. In the latter, on one side they have been drawn back out of the way of navigation, while the other side is not yet finished.

In each end of the jacking girders, there are three pinholes, spaced vertically two feet apart. There is a girder resting under each corner of the suspended span, to which is attached a short link. The top pinhole of this link is to be connected to the slotted pinhole at the bottom of the links hanging from the cantilever arm. Fig. 3 shows a close view of the platforms around the jacking girders, the three pinholes for the link connection.

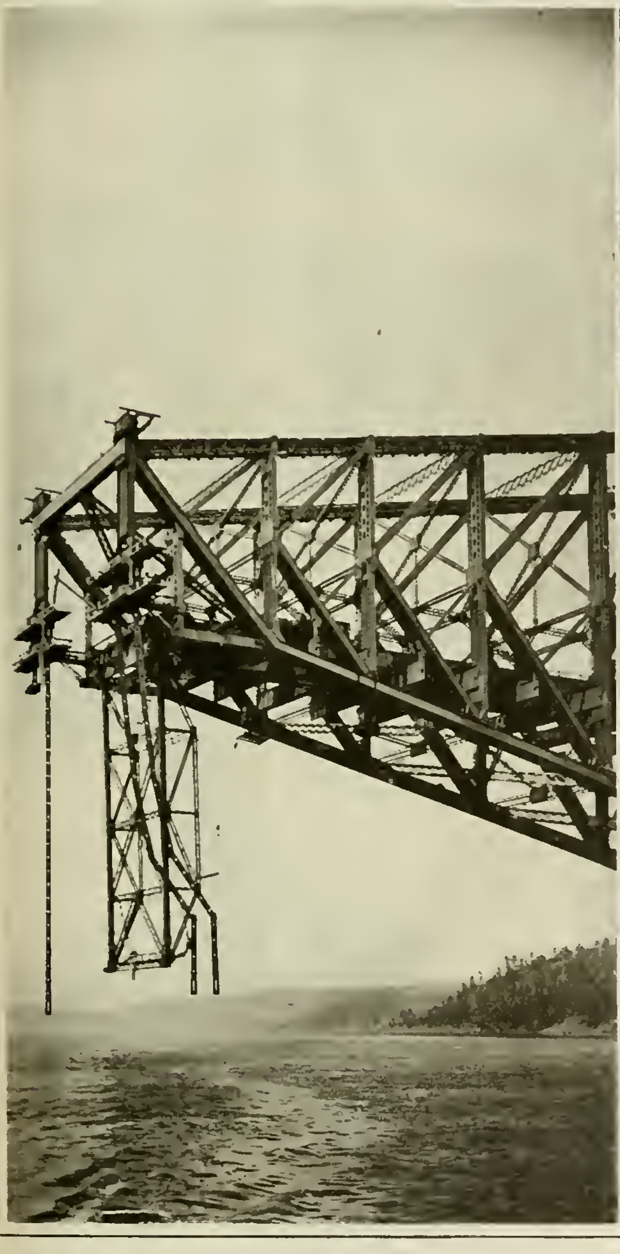


Fig. 2—View Showing Temporary Links.

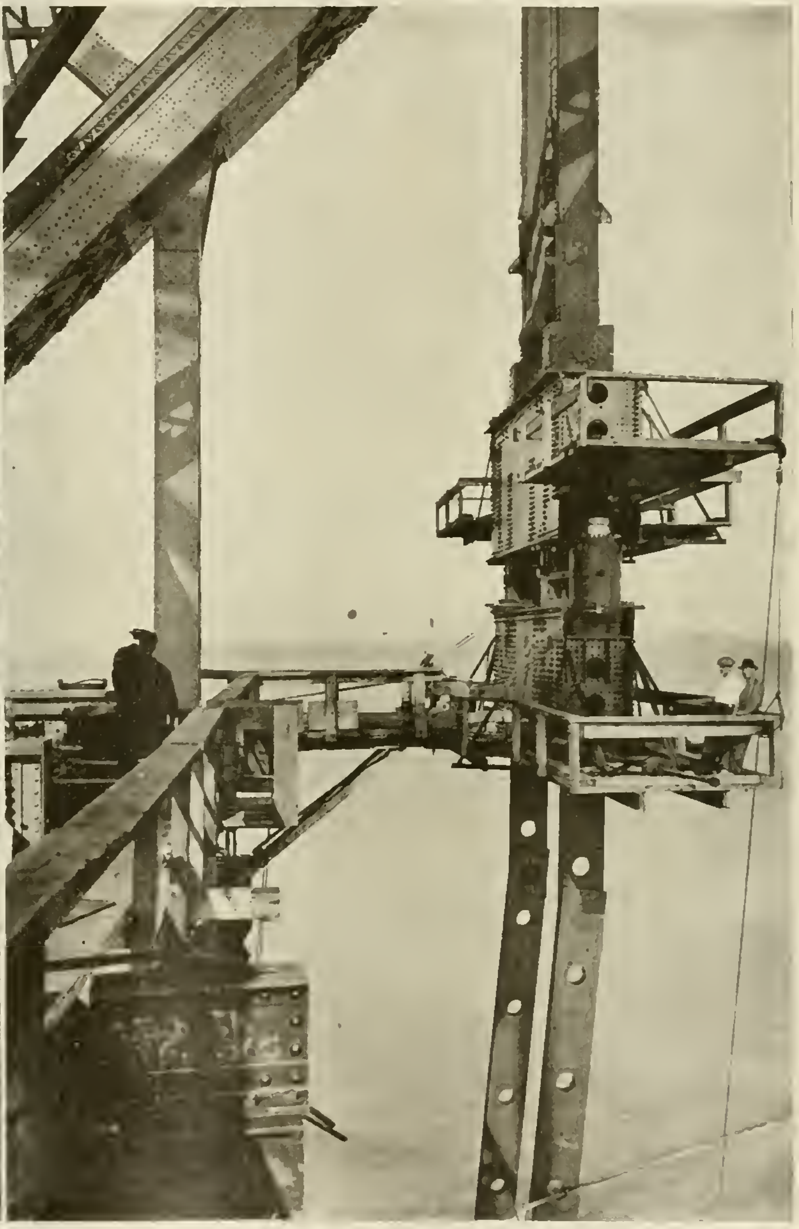


Fig. 3—View of Platforms.

When the day of flotation arrives the valves in the scows will be closed at low tide, so that the span will float at high tide. It will be pulled out into mid stream by tugs and allowed to drift upstream with the incoming tide to a point 150 feet below the bridge where the mooring lines will be made fast, and the span pulled into position. The links will be kept at the right elevation so with the slotted pinholes the connection will be easy to make. The jacking can then be started.

Now assume that at the time of connection the links are connected at pinhole A of the top jacking girder (see Fig. 2) and that the jacks are run up part way. (It is impossible to state exactly the position, as it depends on the height of the tide.) The pumps are now operated, lifting the span until the pin at C on the lower jacking girder may be driven. The screws are now run down, the pin removed from A, the jacks released and the upper girder lowered until the pinhole in the links corresponds to that at C in the upper girder, when the pin will be driven. The span is now jacked up again until the pin may be driven at a, then the jacks released until the connection is made at B. Then up until the pin is driven at b, and then down to A again, after which the process is repeated until the span is in place, the links being removed as soon as they are above the jacking girder. The final pins can now be driven through the eyebars from the cantilever arm and the suspended span (shown spread apart in Fig. 1 for clearness).

All that now remains is the end piece of lower chord containing the friction brake, with a capacity of 250,000 lb. to prevent longitudinal swinging of the span, the bottom laterals in the end panel and the floor system of the suspended span.

At the present writing, August, 1916, the two cantilever arms are completed, as well as the span. The traveler on the South Shore is being taken down, and the riveting is being completed on the span, the North Shore cantilever arm being completed last year. It is hoped to be able to float in the span by September 11, 1916.

The bridge is being built for the Dominion Government, the St. Lawrence Bridge Co., Ltd., being the contractor for the superstructure, of which Phelps Johnson is president, Geo. F. Porter, engineer of construction, and L. P. Mitchell, consulting engineer.

## THE FIRST REGULAR EXAMINATIONS FOR LICENSING STRUCTURAL ENGINEERS IN ILLINOIS.

Elsewhere in this issue appears the advertisement of the Illinois State Board of Examiners of Structural Engineers, indicating that they will hold a regular class examination at the University of Illinois, Champaign-Urbana, on Oct. 19 and 20.

This will be the first regular examination to be held by this Board, which was organized last year, after the passage by the General Assembly and the approval of Governor Dunne of a Structural Engineers' License Law of the State of Illinois, and is consequently attracting considerable attention, not only in the state of Illinois, but also in the country at large, due to the fact that engineers of any locality, in order to prepare plans and specifications for engineering structures in the state of Illinois, must hold a state license. The Illinois law requires that the Board shall publish its rules, officers and examination dates at least twice in one engineering journal of general circulation in the state of Illinois. Incidentally it may be mentioned that the Board is using Engineering and Contracting for this purpose.

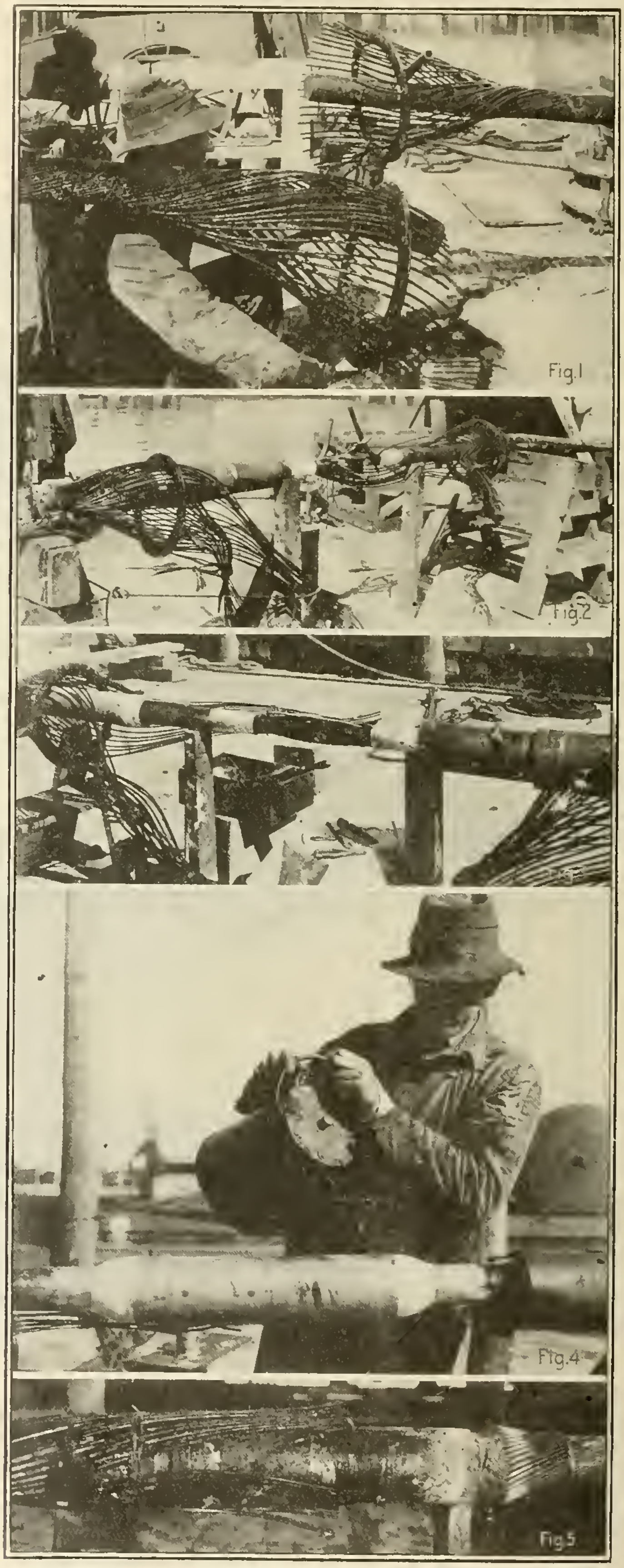
The examination will be of two days duration. The first day will be spent largely in a written examination, covering the design and construction of buildings and structures, according to scientific principles, with special reference to strength and safety; the strength and properties of the various building materials; and the principles of theoretical and applied mechanics. The second day will be spent in testing the ability of the applicant to apply his knowledge to the ordinary requirements in structural engineering, and will consist of a design problem to be worked out by each applicant.

Over a hundred applications for this examination have already been received by the Board, which indicates a wide spread interest in the Structural Engineers' Law of Illinois, and already assures the success of this examination. The Board of Examiners is composed entirely of practical engineers of broad and varied experience, and the examination will be of a broad and common sense nature and not designed in any way to apply to recent graduates or seniors of the technical universities. In order to take the examination an applicant must have had at least six years' experience in the structural engineering field. A degree from an accredited engineering school will count as two years' experience on this required six year period. In addition to having been engaged in the practice of structural engineering for six years, it is necessary that during at least two full years of that time the applicant must have been in responsible charge of work as principal or assistant, with the exception that if he was engaged in the practice of structural engineering in the state of Illinois on the 5th day of July, 1915, and had not applied for a license without examination, he will be permitted to take the examination without regard for the length of time he has practised.

Applications must be on forms provided by the Board, and must be accompanied by the fee of $20.00, which is not returnable in case of failure to pass. Those who are successful will be so advised and upon the payment of an additional fee of $30.00 a license will be issued. Application blanks may be obtained at the office of the Board, 1735 Monadnock Block, Chicago.

## A METHOD OF SPLICING HIGH POWER SUBMARINE ELECTRIC CABLES.

The laying of submarine cable for high power electric transmission is an engineer's task rather than a task for the electrician. This is also largely true of the construction of splices in such cables. A high power submarine cable weighs from 20 to 25 lb. per foot and when it is being laid in water 50 to 100 ft. deep from a vessel subjected to swells and wave action the strains that must



Figs. 1-5—Sequence of Operations in Splicing High Power Submarine Electric Cables.

be withstood by the cable are very great. To strengthen the cable to meet this strain it is spirally wound with steel wires which relieve the lead sheath, the insulation and the conductor wire from damaging pulls. To join this wire sheathing when splices are necessary without forming a weak place in the wire wrapping is a task of importance and the accompanying illustrations show the method of performing this task by the engineers of the Great Western Power Co., San Francisco, Cal., in laying a 22,000-volt submarine cable across San Francisco Bay.

The illustrations indicate the several steps in splicing. Figure 1 shows the wire armor stripped from the cable ends with the wire ends threaded through iron rings to keep them separated and in the proper order. The cable ends are lapped 6 in. The next step is to slip over one of the bared cable ends a turnbuckle sleeve which consists of three parts, as shown by Fig. 2. The sleeve consists of two end pieces of 4½-in. heavy iron pipe with their adjacent ends threaded one to the right and the other to the left and of a coupling of large pipe also right and left threaded screwed partly onto the end parts. This coupling is slipped back onto the cable as shown by Fig. 2, and the conductors are laid bare for splicing. Figure 3 shows the conductors spliced and wound with tape. The fourth operation is to cover the splice with lead sheath as shown by Fig. 4 and to fill the cavity inside this sheath with ozite poured through a hole in the sheath. The turnbuckle sleeve is then slid over the splice sheath and the spiral wires are cut, drawn tight and welded by oxy-acetylene process to the ends of the sleeve pieces. Figure 5 shows the turnbuckle sleeve with the wires welded to one end and laid in place ready to cut and weld to the other end. When both welds are completed the coupling piece is screwed up, pulling the end pieces toward each other and placing the armor wires tight.

From a paper by J. A. Koontz and L. P. Cornell, engineers of the Great Western Power Co., read before the San Francisco Section of the American Institute of Electrical Engineers, we take the following further information concerning the splicing of this long power cable:

Elaborate tests were made before these splices were adopted. A tension of 28 tons was applied to both the armor and conductors on each side of the sleeve, first lengthwise and then by confining the turnbuckle parallel to the floor and hoisting both ends of the cable on the hook of a crane at right angles to it. This test was stopped at 28 tons because that happened to be the limit of the ring bolt in the concrete floor. A potential test of 53,400 volts was applied for five minutes between conductors without failure, and was stopped at this point because of the brush discharge between the ends of the conductors. A tension of 100 tons was later applied to the armor wires on each end of a section of the cable without causing measurable elongation or any change in its appearance.

The cable laying barge was 86x35 ft., equipped with a reel of ordinary type 6-ft. drum, 16 ft. long, gear driven by a steam engine. The capacity of the barge was 200 tons, of the reel 125 tons. The cable was furnished by the General Electric Co. in lengths of 1,000 and 1,308 ft. Several of these lengths were joined together to form a section suitable for laying while the barge was tied at the dock, and this work proceeded at the rate of a splice a day.

To accomplish this result the men worked in rotation. The cable splicer and his helper started the day and were followed by the welder, and he in turn by five stevedores and the donkey engineer, who placed the cable on the reel and made ready for the next splice.

When a section of desired length was formed the barge went out and laid it and returned to the dock, where the operation was repeated.

At the start, 11¼ hours elapsed in making a splice, of which 4 hours were used in welding the armor. Toward the last the workmen became more expert and finished splices required only 6½ hours, of which 50 minutes elapsed in welding each end of the armor. Fourteen splices were made under these conditions.

## HINTS ON CONCRETING IN COLD WEATHER.*

Concrete work can be carried on successfully in cold weather. All that is necessary is to heat the sand and pebbles or broken stone and mixing water so that the concrete mixture will have a certain minimum temperature, then to place the concrete quickly and maintain the heat until early hardening has been completed. This does not mean that there are no limitations to the practicability of doing concrete work in cold weather, but that if a few simple precautions and protective measures are used, winter concrete work will be as successful as that done in warm weather.

Many contractors have found their working season profitably lengthened by using these precautions and protective measures. This means that men and equipment can be kept profitably employed almost regardless of season. In this way the contractor can keep his efficient organization together. The resulting advantages are far greater than the seeming disadvantages—principal among which is that applying the necessary precautions slightly increases the cost of cold weather work. This, however, is usually offset by the builder's willingness to pay for the privilege of having the use of his building or structure earlier than would be possible if work were postponed until warm weather.

REMEMBER that during the first few days following the placing of concrete, alternate freezing and thawing at comparatively short intervals will damage it.

REMEMBER, therefore, that it is necessary to so mix, place and protect the concrete that early hardening will be complete before the work is exposed to freezing temperatures.

REMEMBER that to do this:

(1) Sand and pebbles or broken stone used must be free from frost or lumps of frozen material.

(2) If these materials contain frost or frozen lumps, thaw them out before using.

(3) As cement forms but a relatively small bulk of the materials in any batch of concrete, it need not be heated.

(4) Mixing water should always be heated.

REMEMBER that although adding common salt to mixing water will prevent freezing of concrete that has not hardened, there is a limit to the quantity of salt which may be added if the final strength of the concrete is not to be affected. Salt simply lowers the freezing point of the mixing water; it does not supply what is most needed—heat and warmth. It delays, instead of hastens, the hardening of the concrete.

REMEMBER that sand and pebbles or broken stone and mixing water must be heated so that the concrete when placed shall have a temperature of from 75 to 80 degrees.

REMEMBER that some sands are injured by too much heat. The same applies to certain varieties of pebbles and broken stone. A temperature not exceeding 150 degrees Fahrenheit will generally prove most satisfactory.

REMEMBER to place concrete immediately after mixing so that none of the heat will be lost before placing in the forms.

REMEMBER to warm metal forms and reinforcing before placing concrete. Be careful to remove ice and snow and frozen concrete remaining on the forms from preceding work. Forms can be warmed by turning a jet of steam against them or by wetting with hot water.

REMEMBER that even though materials have been heated and the concrete placed immediately after mixing, it will lose much of its heat if not protected from low temperatures.

REMEMBER, therefore, to protect the concrete immediately after placing. Canvas covering, sheathing, housing-in the work, or hay or straw, properly applied will furnish the required protection for some work. In addition to these means, small oil or coke burning stoves or salamanders may be used in enclosed structures.

REMEMBER that temperatures which may not be low enough to freeze the concrete may, nevertheless, delay its hardening for a considerable time. Do not expect concrete placed when the temperature is low and remains low for some time afterward to be safe for use as soon as though placed during warmer weather.

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*Data issued by Portland Cement Association, Chicago, Ill.

REMEMBER that if concreting is unavoidably delayed or interrupted the work should be covered until concreting is again begun.

REMEMBER to cover and protect any sections of the work as soon as completed. In severe cold weather, continue this protection for at least five days.

REMEMBER that forms must not be removed from the concrete work too early. This applies to any concrete work, regardless of season, but is particularly important with work done during cold weather.

REMEMBER that frozen concrete sometimes very closely resembles concrete that has thoroughly hardened. When frozen concrete is struck with a hammer, it will often ring like properly hardened concrete. Before removing forms, examine the work carefully to see whether it has hardened or is simply frozen. To determine this, remove one board from some section of a form, pour hot water on the concrete or turn the flame of a plumber's blow torch or a jet of steam under pressure against the concrete. If frozen, the heat will soften the concrete by thawing the water contained in it.

REMEMBER that although concrete which freezes before early hardening has been completed may not be permanently injured, if after thawing out it is not again exposed to freezing until hardened, protecting the concrete against possibility of freezing is best.

REMEMBER to write to the Portland Cement Association, 111 West Washington street, Chicago, for its booklet, "How to Do Concrete Work in Cold Weather."

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## CONCRETE EQUIVALENTS FOR STEEL BEAMS.

Contributed by Geo. A. Merrill, Boston, Mass.

With the present high cost of structural steel an architect or contractor often has occasion to change over a layout of steel beams and concrete slabs to one where the steel beams are eliminated and concrete tee beams substituted.

The following table is offered to facilitate the work of the architect in calculations and to aid the contractor in making up on estimate. The basis of the table is the varying resisting moment of the steel beam when stressed up to 16,000 pounds per sq. inch. Inasmuch as steel beams must be figured without any value given to continuity, while in reinforced concrete design this principle is used, any structural steel beam will have three concrete equivalents, according as the continuity is full, partial, or nil.

It is assumed in the table that the concrete slab is four inches thick, and that the equivalent concrete beam is four inches deeper than the steel beam, giving the same depth over all as the steel beam when fireproofed two inches under the bottom flange.

An example of one steel beam, 12 in. × 31½ ft. worked out in detail will sufficiently explain the table.

12 in. × 31½ ft. Resisting moment 47,960 ft. lbs.

$$M \frac{WL}{8} \text{ R. M.} = 47,960 \text{ ft. lbs. } f_c = 650$$

$$M = \frac{WL}{10} \text{ R. M.} = 38,368 \text{ ft. lbs. } f_s = 16,000$$

$$M = \frac{WL}{12} \text{ R. M.} = 31,973 \text{ ft. lbs.}$$

$$\frac{47,960 \times 12}{16,000 \times \frac{7}{8} \times 14} = 2.94\square \text{ or } 3.1\square \text{ bars. Bm. 10x16}$$

$$\frac{38,368 \times 12}{16,000 \times \frac{7}{8} \times 14} = 2.35 \text{ or } 2.1\square\ 1\tfrac{5}{8} \text{ Beam 10x16}$$

$$\frac{31,973 \times 12}{16,000 \times \frac{7}{8} \times 14} = 1.96 \text{ or } 2.1\square \quad \text{Beam 8x16}$$

Maximum and shear at 120 lbs. per sq. in. =
10 × 14 × ⅞ × 120 = 14,700 lbs. or W = 29,400 lbs.

$$47,960 = \frac{29,400L}{8} \text{ or } L = 13', \text{ the minimum allowable}$$

length of equivalents 10x16 beam.

For 8x16 beam, maximum end shear = 8 × 14 × ⅞ × 120 = 11,760 lbs., or W2 23,520.

$$31,973 = \frac{23,520L}{12} \text{ or } L = 16.5'.$$

The weight of reinforcement per linear foot of beam is obtained by adding 20 per cent to weight of main bars, to cover laps and stirrups.

The cubic feet of concrete per linear foot of beam is the amount of concrete below bottom of four inch slab.

The column of forms is the board feet of length per foot of beam, taking slab as four inches thick. It includes posts and braces for a twelve-foot story height with posts three feet centers.

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## MASTIC FLOORING FOR INDUSTRIAL BUILDINGS.

(Contributed.)

The widely different working conditions encountered in modern industrial buildings demand a flooring material which will stand up under all kinds of service. In one instance, the floors are subjected to the wear and tear

TABLE FOR USE IN CALCULATING CONCRETE EQUIVALENTS FOR STEEL BEAMS.

| | Concrete beam; $M = \frac{WL}{8}$ | | | | | | | Concrete beam; $M = \frac{WL}{10}$ | | | | | | | Concrete beam; $M = \frac{WL}{12}$ | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Reinforcement. | | | | | | | Reinforcement. | | | | | | | Reinforcement. | | | | | |
| Steel beam. | Beam size. | Number and size of square bars. | | Wt. rein. per ft. of beam, lbs. | Cu. ft. conc. per ft. | Bd. ft. forms per ft. | Min. length beam, ft. | Beam size. | Number and size of square bars. | | Wt. rein. per ft. of beam, lbs. | Cu. ft. conc. per ft. | Bd. ft. forms per ft. | Min. length beam, ft. | Beam size. | Number and size of square bars. | | Wt. rein. per ft. of beam, lbs. | Cu. ft. conc. per ft. | Bd. ft. forms per ft. | Min. length beam, ft. |
| 24x100 | 14x28 | 5 1⅛ | 3 1 | 39.3 | 2.33 | 15.3 | 29.0 | 12x28 | 5 1⅛ | 1 1 | 30.0 | 2.0 | 15.0 | 33.5 | 12x28 | 5 1 | 1 1⅛ | 25.6 | 2.0 | 15.0 | 33.5 |
| 24x80 | 14x28 | 8 1 | | 32.6 | 2.33 | 15.3 | 25.5 | 12x28 | 4 1 | 2 1⅛ | 26.7 | 2.0 | 15.0 | 29.5 | 12x28 | 4 1 | 2 ⅞ | 22.5 | 2.0 | 15.0 | 29.5 |
| 20x80 | 14x24 | 8 1 | | 32.6 | 1.94 | 14.1 | 25.5 | 12x24 | 4 1 | 2 1⅛ | 26.7 | 1.67 | 13.8 | 29.5 | 12x24 | 3 1 | 2 1⅛ | 22.6 | 1.67 | 13.8 | 29.5 |
| 20x65 | 12x24 | 4 1 | 2 1⅛ | 26.7 | 1.67 | 13.8 | 23.5 | 12x24 | 4 1 | 1 1⅛ | 21.5 | 1.67 | 13.8 | 23.5 | 10x24 | 2 1 | 2 1⅛ | 18.5 | 1.39 | 13.5 | 28.5 |
| 18x55 | 12x22 | 3 1 | 2 1⅛ | 22.6 | 1.50 | 13.4 | 20.0 | 12x22 | 3 1 | 2 ⅞ | 18.4 | 1.50 | 13.4 | 20.0 | 10x22 | 5 ⅞ | | 15.6 | 1.25 | 13.1 | 24.0 |
| 15x50 | 12x19 | 3 1 | 2 1⅛ | 22.6 | 1.25 | 12.4 | 17.0 | 12x19 | 3 1 | 2 ⅞ | 18.4 | 1.25 | 12.4 | 17.0 | 10x19 | 5 ⅞ | | 15.6 | 1.04 | 12.1 | 20.5 |
| 15x42 | 12x19 | 3 1 | 2 ⅞ | 18.4 | 1.25 | 12.4 | 15.5 | 10x19 | 2 1 | 2 ⅞ | 14.3 | 1.04 | 12.1 | 19.0 | 10x19 | 3 1 | | 12.2 | 1.04 | 12.1 | 19.0 |
| 12x40 | 10x16 | 4 1 | | 16.3 | .83 | 11.2 | 17.5 | 10x16 | 2 1 | 2 ⅞ | 14.3 | .83 | 11.2 | 17.5 | 10x16 | 2 1 | 1 ¾ | 10.5 | .83 | 11.2 | 16.5 |
| 12x31$^{5}$ | 10x16 | 3 1 | | 12.2 | .83 | 11.2 | 13.0 | 10x16 | 2 1 | 1 ⅝ | 9.8 | .83 | 11.2 | 13.0 | 8x16 | 2 1 | | 8.2 | .67 | 11.1 | 16.5 |
| 10x25 | 10x14 | 2 1 | 1 ⅝ | 9.8 | .69 | 10.4 | 10.5 | 8x14 | 2 1 | | 8.2 | .56 | 10.4 | 13.0 | 9x14 | 3 ¾ | | 7.0 | .63 | 10.4 | 11.5 |
| 9x21 | 8x13 | 2 1 | | 8.2 | .50 | 10.1 | 11.0 | 9x13 | 3 ¾ | | 7.0 | .56 | 10.1 | 10.0 | 8x13 | 2 ⅞ | | 6.2 | .50 | 10.1 | 11.0 |
| 8x18 | 9x12 | 3 ¾ | | 7.0 | .50 | 10.0 | 8.0 | 8x12 | 2 ⅞ | | 6.2 | .44 | 10.0 | 9.0 | 8x12 | 2 ¾ | | 4.7 | .44 | 10.0 | 9.0 |
| 7x15 | 8x11 | 2 ⅞ | | 6.2 | .39 | 9.4 | 7.5 | 8x11 | 2 ¾ | | 4.7 | .39 | 9.4 | 7.5 | 8x11 | 2 ¾ | | 4.7 | .39 | 9.4 | 7.5 |
| 6x12$^{25}$ | 8x10 | 2 ¾ | | 4.7 | .33 | 9.0 | 6.0 | 8x10 | 2 ¾ | | 4.7 | .33 | 9.0 | 6.0 | 6x10 | 2 ⅝ | | 3.2 | .25 | 9.0 | 8.0 |
| 15x33 | 8x19 | 3 1 | | 12.2 | .83 | 12.2 | 16.5 | 8x19 | 2 1 | 1 ⅝ | 9.8 | .83 | 12.2 | 16.5 | 8x19 | 2 1 | | 8.2 | .83 | 12.2 | 16.5 |
| 12x20$^{5}$ | 8x16 | 2 1 | | 8.2 | .67 | 11.1 | 10.0 | 8x16 | 2 ⅞ | | 6.2 | .67 | 11.1 | 10.0 | 8x16 | 2 ⅞ | | 6.2 | .67 | 11.1 | 10.0 |
| 10x15 | 8x14 | 2 ¾ | | 4.7 | .56 | 10.4 | 7.0 | 8x14 | 2 ¾ | | 4.7 | .56 | 10.4 | 7.0 | 8x14 | 2 ¾ | | 4.7 | .56 | 10.4 | 7.0 |
| 9x13$^{25}$ | 8x13 | 2 ¾ | | 4.7 | .50 | 10.1 | 6.0 | 8x13 | 2 ¾ | | 4.7 | .50 | 10.1 | 6.0 | 6x13 | 2 ⅝ | | 3.2 | .50 | 10.1 | 8.0 |
| 8x11$^{25}$ | 8x12 | 2 ¾ | | 4.7 | .44 | 10.0 | 5.5 | 6x12 | 2 ⅝ | | 3.2 | .33 | 10.0 | 7.0 | 6x12 | 2 ⅝ | | 3.2 | .33 | 10.0 | 7.0 |
| 7x9$^{75}$ | 6x11 | 2 ⅝ | | 3.2 | .29 | 9.4 | 6.0 | 6x11 | 2 ⅝ | | 3.2 | .29 | 9.4 | 6.0 | 6x11 | 2 ⅝ | | 3.2 | .29 | 9.4 | 6.0 |
| 6x8 | 6x10 | 2 ⅝ | | 3.2 | .25 | 9.0 | 5.0 | 6x10 | 2 ⅝ | | 3.2 | .25 | 9.0 | 5.0 | 6x10 | 2 ⅝ | | 3.2 | .25 | 9.0 | 5.0 |

from the handling of machinery and heavy trucking, while in the other, light traffic, either foot or wheel, is the only service condition encountered. The limitations of most floors stop their general use in meeting such widely different requirements efficiently. For these reasons, a flooring which possesses the ability to meet such a wide range of conditions is becoming more and more a necessity and will undoubtedly be used eventually in the majority of industrial plants throughout the country.

A floor made up of a mastic of hard aggregate, cemented together with bituminous compounds, is proving itself adaptable for practically all service conditions and is now being specified in a number of buildings where the conditions are as already outlined. Probably the most widely used flooring of this type is a product manufactured by the H. W. Johns-Manville Co., known as J-M Mastic Flooring, and which is meeting with great success.

This floor consists of a selected mineral aggregate of either crushed limestone, granite or torpedo gravel, with particles ranging from a size passing a ¼-in. screen down to those which will pass a 200-mesh. Trinidad Lake asphalt, combined with other natural asphalts, forms the cementing base of this floor.

Success with this type of floor demands a careful grading of the aggregate particles and their intimate mixture with the cementing materials in a manner that will insure the densest possible product in which even the finest particles are thoroughly coated with asphalt. To insure that this will be properly done in the J-M floor, the aggregate passing a 60-screen are combined with the asphalt at the plant rather than at the site of the work. They are heated and mechanically agitated for a period of six to seven hours and then molded into blocks of convenient size for shipment.

On the work these blocks are broken up and reheated to a temperature of 450 deg. F., and mixed with a coarse aggregate, using a pure asphalt flux. The resulting softened mass is transported to the work in oak buckets or iron wheel-barrows and is laid down in one or two courses depending upon the required thickness and troweled to the desired surface.

This floor can be made in any consistency between extreme hardness and softness and while it is always dense, it possesses a certain amount of resiliency which greatly adds to the comfort of those who work and walk on it.

It is found that this flooring is very sanitary on account of its one-piece monolithic surface, which has neither cracks nor crevices to harbor dust or moisture. It is easily cleaned by flushing and dries quickly.

J-M Mastic Flooring is easily laid and, if changes in the floor surface are made necessary, it is easily repaired. It adds very little to the dead load, as the standard thickness of $1\frac{1}{2}$ in. weighs only 18 lb. to the square foot when applied. This thickness is sufficient for ordinary trucking requirements, but can be varied to meet conditions, from 1 in., where the requirements are very light, such as foot traffic, to 3 in. in thickness for loading docks where the requirements are correspondingly severe.

The application of this flooring is comparatively simple and it can be laid over any foundation which is firm and stable, such as wood, brick, concrete or tile already in place.

View Showing Method of Applying Mastic Flooring.

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## $100 IN PRIZES FOR ENGINEERS' PAPERS.

The Engineers' Subdivision of the Chicago Association of Commerce has offered three cash prizes—$50, $30 and $20—for the three best papers, not to exceed 3,000 words, on any one of the following subjects:

(1) "Engineering and Civic Progress."

(2) "The Engineer of the Future."

(3) "The Business Relation of the Engineer to the Commercial World."

The contest is open to undergraduates and graduates of any recognized school of engineering in the United States during the years 1915 and 1916.

Relationship of the engineer and of engineering to the business and professional world; how best to realize the conceived ideal of engineering, concrete examples illustrative of the true significance of engineering, such as a brief prospectus of a proposed work or a short, crisp, readable news article on a piece of engineering construction—these are suggested lines for development.

The judges of the relative merits of the papers will be F. H. Newell, professor of civil engineering, University of Illinois; John W. Alvord, consulting engineer, Chicago, and John F. Hayford, director, College of Engineering, Northwestern University.

All papers should be mailed to Engineers' Subdivision Contest, The Chicago Association of Commerce, 10 South La Salle street, Chicago, and must be received not later than Nov. 1, 1916.

## AN INVESTIGATION OF COMPOSITION FLOORING.*

In 1867 Sorel found that a very hard material might be produced by mixing magnesia and a solution of magnesium chloride and then allowing the mixture to stand for some time. During the past 25 years Sorel cement has been extensively employed with success as a cementing material for so-called "composition flooring." According to European practice, the magnesia, mixed with various "fillers," such as sawdust, sand, terra alba, infusorial earth or asbestos, and colored with different inorganic colors, is made into a "mortar" by the addition of a solution of magnesium chloride; the material is then applied to the floor and leveled, and, after standing several hours, it is carefully troweled. After 8 or 10 hours the cement sets and the surface of the flooring is then usually treated with a coat of oil, after which the composition is ready for use.

The composition is usually applied in two coats: an under fibrous coat, about 5/16 in. thick, and an upper coat containing less fiber, from 5/16 to ½ in. thick. The under fibrous coat imparts elasticity to the material and renders the floor noiseless and pleasant to the tread. In fact, this composition does not give rise to the fatigue experienced from the use of stone, cement, terrazzo or other hard floors. Furthermore, even when troweled to a very smooth surface, this composition does not produce a slippery floor. These advantages, along with the facts that the composition costs less than tile, marble, etc., and that it will outwear eight or ten applications of linoleum, have made it a very popular floor material in Europe, especially in Germany and England.

Composition flooring of the general type described above was introduced into the United States a short time after it came into favor abroad. American manufacturers have, however, experienced considerable difficulty in the use of Sorel cement. Some have attributed this to the differences in the climatic conditions of Europe and America, the contention being that the sudden changes of temperature encountered in the United States are not experienced abroad, particularly in England and Germany. Others have expressed the opinion that the principal cause of the failure in this country is attributable to the mixtures employed: the assertion has been made that the mixtures in use here have been neither scientifically nor even carefully prepared. Inasmuch as many of the floors examined by the author are as perfect as could be desired, he is inclined to favor the latter explanation. If the trouble is due to the sudden climatic changes, why should one floor be affected and not another in the same locality?

In 1911 in New York City alone there were at least 20 firms engaged in the composition-flooring business, and the competition was very keen indeed. All of the companies were cutting prices in order to secure business and many of the firms were putting down the cheapest mixtures which they could conceive. In fact, everything possible was being done to minimize the cost of the product, without much regard for the requirements of a correctly made mixture. The components of the mixtures were weighed and mixed by ordinary laborers, so that it was quite impossible for the mixtures to be of a definite consistent composition. Consequently, all of the manufacturers were experiencing decided trouble with their floors. To illustrate, the color frequently "went bad"; some floors would crack or bulge, and at no time could they be assured of a satisfactory floor. As a result, many floors had to be relaid. Then, too, the cost of magnesite was constantly increasing, labor costs were high, and the selling price was so low that it was impossible to make a reasonable profit out of the business.

At the time of this investigation, the red mixture in use by the donors of the Hydrolith Fellowship† was supposed to contain:

| Ingredients: | Magnesite. | Sawdust. | Red color. | Clay. | Terra alba. | Infusoria earth. |
|---|---|---|---|---|---|---|
| Percentages ... | 50 | 9 | 10 | 11 | 10 | 10 |

Some very good floors were made from this composition and again some could not have been worse. In some cases the floors expanded, while in other cases they contracted and cracked badly. Then, in certain of the floors, the color faded decidedly, so that in a short time the appearance became very unattractive.

The investigation conducted by the author at the Mellon Institute of Industrial Research included overcoming the change in color, obviating the expansion and contraction, and reducing the cost in any legitimate way.

The first experiments carried out were for the determination of the correct amount of magnesite and magnesium chloride to be used, the effect of different fillers, and the results of working samples in various ways. Red colored mixtures were used in this series, which consisted of 1,000 samples. All of the materials entering into the compositions were carefully weighed, made up into 500-gram samples and thoroughly mixed before the addition of the magnesium chloride solution, the strength and amount of which were also very accurately determined.

The results of this series of experiments showed that with the fillers employed it was necessary to have present not less than 8 or 9 per cent of magnesium chloride and from 20 to 30 per cent of commercial magnesia. When an extremely hard and durable flooring composition was desired, still larger amounts were required. In samples where more than 1 part of magnesium chloride was employed to 3 parts of magnesia, there was always a tendency for the excess of magnesium chloride to come to the surface.

In a number of experiments, terra alba was the only filler employed with the exception of sawdust; in others infusorial earth was used, while in still others clay was the only filler besides sawdust. These tests were carried out in parallel, i. e., each day samples were made containing the same percentage of magnesium chloride and magnesite with the same percentage of each of the different fillers. This was done for the purpose of studying the relative effect of each filler and to ascertain whether all acted in the same manner. The only noticeable differences were in the samples in which clay and infusorial earth were employed. Since these substances are lighter than terra alba, it was found that the samples covered more space than those in which terra alba alone was used. It was also learned that, on account of the greater bulk of these substances, they hardened more slowly and invariably gave less hard samples than those in which terra alba alone was employed. The terra alba samples hardened first, those containing infusorial earth next, and the ones with clay last. Clay quite appreciably retarded the settling of the cement.

Determinations were made of the least amount of color which could be used to obtain the desired shade. Varying amounts of Venetian red were employed, and it was ascertained that 10 to 12 per cent were necessary. Determinations were also made of the greatest amount of sawdust which could be used to obtain a floor which would not be liable to expand or contract and would yet be of sufficient hardness. It was found that samples containing 6 to 8 per cent of sawdust were very hard and did not impart the proper resistance or elasticity to the floor; but that samples with 10 to 12 per cent, according to the other fillers used, were very satisfactory. Samples containing a higher percentage of sawdust hardened very slowly and those with from 16 to 20 per cent of this material were always quite soft after drying. It was found, however, that this large amount of sawdust could be used with advantage in the under fibrous coat.

Following the completion of this preliminary work, the author superintended the laying of a floor of 550 sq. ft., following the formula which had given the best results in the laboratory experiments, the composition being:

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*From a paper by R. R. Shively, presented at the spring meeting of the American Chemical Society.

†Industrial Fellowship No. 2 at Mellon Institute of Industrial Research of the University of Pittsburgh. The matter in this article represents the result of a part of the work done during Mr. Shively's tenure of this fellowship.

| Ingredients: | Magnesium chloride. | Magnesia. | Sawdust. | Red color. | Clay. | Terra alba. |
|---|---|---|---|---|---|---|
| Percentages ..... | 10 | 40 | 10 | 12 | 20 | 8 |

The materials were carefully weighed and thoroughly mixed, the dry mixture was then incorporated with the calculated amount of magnesium chloride solution and water was added until the proper consistency was attained. The mixing was continued until all lumps had disappeared and the mixture was then applied over metallic laths. It hardened slowly, but, when hard, it gave a perfect floor which exhibited no physical changes after the expiration of 6 months.

A second series of experiments was taken up in order to determine the effect of different fillers upon the hardness, color and surface of the floor and the effect of various combinations of fillers. It was thought that such an investigation would supply information which would enable one to select the materials giving best results, and that if there was no difference in the results obtained by the employment of various fillers, the cheapest thereof could be selected.

It was found that in samples containing small percentages of magnesium chloride and oxide, the hardening occurred much more slowly than when a greater percentage of the actual cementing material was used. In samples containing high percentages of terra alba, infusorial earth or clay, the difference in the time of setting was quite noticeable: without exception, the samples containing terra alba hardened first, those containing infusorial earth next, and those filled with clay last. In samples with higher percentages of cement, this difference was not so pronounced, but still it could be observed. In all experiments wherein these ingredients were added as the only mineral filler, the terra alba samples were hardest, and there was little, if any, difference between the clay and the infusorial earth samples. It is, of course, a question as to whether this hardness will cause a floor to wear longer than a floor with more resilience which gives, rather than wears. If, however, such hardness is desirable, it can be attained by using greater percentages of cement with the clay and infusorial earth. In none of the samples could any apparent objection be found to any of the fillers in reference to their effect on the surface. All samples, whether containing but one filler or all three, appeared to give the same finish. It was found, however, that when the samples contained a large percentage of clay or infusorial earth, it was necessary to use more color.

Regarding the amount of magnesite and magnesium chloride necessary; the results of this series of experiments showed clearly that never more than 40 per cent of magnesite or 12 per cent of magnesium chloride could be employed. In tests where more than these percentages were used, a very hard floor was obtained, whereas the smaller amount gave a sufficiently hard composition. The only samples in this series of experiments which showed a tendency to develop physical defects were those which contained high percentages of magnesite and magnesium chloride. In every case where the percentage of magnesium chloride was more than one-third that of the magnesite, there was a tendency for the excess chloride to come to the surface.

In a third series of experiments an effort was made to study the relation of the mass of composition to the volume of magnesium chloride solution sufficient to make a mixture of the proper consistency for laying. This was considered important, since, in preparing the mixture, the workmen invariably used a sufficient amount of magnesium chloride solution of a certain degree Baume regardless of the actual magnesium chloride contained therein. For example, it was customary to use a 21° B. solution in summer and an 18° B. solution in winter. Accordingly, solutions of these strengths were used in the experiments. The solid constituents of the mixture were made up of 250 gram and to these samples enough magnesium chloride solution was added to obtain the proper consistency for laying. From the amount of solution required, the actual weight of the magnesium chloride used was calculated, and from this the percentage of magnesium chloride in the finished product was computed.

The average amount of magnesium chloride solution required for 32 samples of this composition was 178 cc. with a maximum of 225 cc. and a minimum of 160 cc. The average amount of magnesium chloride added in per cent was 11.1 for the 18° B. solution and 13.3 for the 21° B. solution. The maximum percentage required for the 18° B. solution was 13.8 and the minimum 10.2. It was found that mixtures containing a large amount of clay or sawdust required enough of the magnesium chloride solution in mixing to bring the percentage of magnesium chloride above the 1:3 limit; in such samples it was found that there was always a tendency of the floor to warp on standing.

These experiments demonstrated that, in order to obtain the best results, the strength of the magnesium chloride solution should be known and just sufficient of it should be added to secure the correct percentage of magnesium chloride with enough additional water to obtain the proper consistency.

In connection with the third series of experiments, slate was used as the coloring material, but it was found to give very uncertain results. Talc was also tried as a filler and it was found that, when used in moderate amounts, it aided greatly in giving the floor a luster when properly troweled; moreover, the tests showed that it slightly decreased the absorption of the material. When too much talc is used, however, it constantly comes to the surface, especially after the sample is washed and allowed to dry slowly. Some experiments which were made to determine the largest amount of sawdust that could be used showed that the greatest that could be safely and successfully employed was 15 per cent. In these samples, it was necessary not to have an excess of magnesium chloride, for bad warping occurred when too much was used. Sand was also experimented with as a filler and it was found that a very hard composition resulted with a large percentage of sand. While it is difficult to obtain sand of such fineness as to permit of the production of a very smooth surface, it aids in producing a hard, durable floor.

The results of ten other experimental series may be briefly noted. Efforts to find a substitute for Venetian red established the fact that while hematite of desired color would cost, when using 25 per cent of color, at least two-thirds as much as Venetian red, the color obtained was one that did not meet with general approval and twice as much was required to produce the same color intensity as that imparted by the prepared color. In connection with reducing the cost of the color, about 30 samples were made in which aniline dyes were used: none of these retained their color for any length of time.

In one series in which varying amount of sawdust and asbestos were used, it was found that when used in too great quantities, asbestos interfered somewhat with the troweling; the results obtained indicated that not more than 5 per cent of asbestos should be employed, since greater amounts interfered with the production of a good surface.

A series of experiments was carried out for the purpose of studying the effect of adding oil to the composition and then comparing the absorption of samples made from different fillers. The samples were all made on the same day and an attempt was made to trowel each sample in the same manner. In the samples in which oil was used, the oil was thoroughly mixed therewith, and then these samples were brought to the proper consistency by the use of a calculated amount of concentrated magnesium chloride solution and water. The samples were allowed to stand one week and then a part of each sample was used for an absorption test. The samples were weighed, immersed in water for 24 hours, and reweighed. These samples were then placed aside for 4 minutes, weighed, immersed in water, and then reweighed. The absorption was not proportional to the amount of oil used, but, after the samples had stood for some time, they all absorbed more water, with the exception of those in which linseed oil was used. These showed no indication of oil on the surface, while those in which hard mineral oil was used possessed an oily appearance. The results indicated that the magnesium linoleate acted as a binder between the particles, thus lowering the absorption. The samples in which a small amount of oil was used were sufficiently hard; but, when a large amount of oil was employed, several months of standing were necessary for the samples to become satisfactory in this respect. The samples without oil faded badly after the absorption test, while little change could be observed in the color of the samples which contained oil. Invariably, the samples containing oil set more slowly.

Experiments were conducted with the object of reducing the cost of the composition by employing other materials with reduced amounts of magnesite. Portland cement-magnesite mixtures had a bad color, absorbed a large amount of water and shrank on drying; in general, they resembled more closely the cement than the composition floors. Plaster of Paris gave compositions which dusted badly, lacked hardness, and set too quickly. Likewise, gypsum which had been heated to 400° C. gave samples which set too quickly and were no harder than the samples made from ordinary plaster of Paris. Samples prepared with the addition of cement made of molecular quantities of magnesia, magnesium sulfate and plaster of Paris, said to form a white, quick-setting strong cement, also set quite quickly and were very hard, but the material rubbed off easily.

In the effort to find the material which would be a suitable binder for fillers or one that could well be used as a surface material, a number of experiments were made with asphalt, "Redmanite," gelatin-glycerol mixtures, "Galalith," viscose and vegetable resins. No results of commercial importance were obtained.

Finally, it may be mentioned that in 1912 a section of a floor, 12 ft. by 16 ft., was laid in a factory room which was in constant use; this floor was put down in the center of the room and was subjected to a great deal of wear. It was scrubbed every day with alkaline cleansing material and hot water. At the end of 7 months the floor was reported to be entirely set and as good as terrazzo. Further experience warranted the conclusion that the flooring, the composition of which was identical with that laid in 1911, noted above, was more desirable than a floor constructed from a hard, nonpliable, highly conductive substance like terrazzo.

The successful working of composition flooring of the type considered does not depend entirely upon the chemical composition, but also upon the mechanical manipulation. The exercise of constant care is necessary in laying the floor and consequently only skilled workmen should be employed in practice; in particular, composition flooring should not be over-troweled, and the necessary precautions should always be taken in laying floors over surfaces which are subjected to heat. The composition should be dependent upon the uses to which the floor is to be put; but a formula is given which, when suitably modified along the lines indicated and expertly used, will comply with the conditions usually encountered in practice.

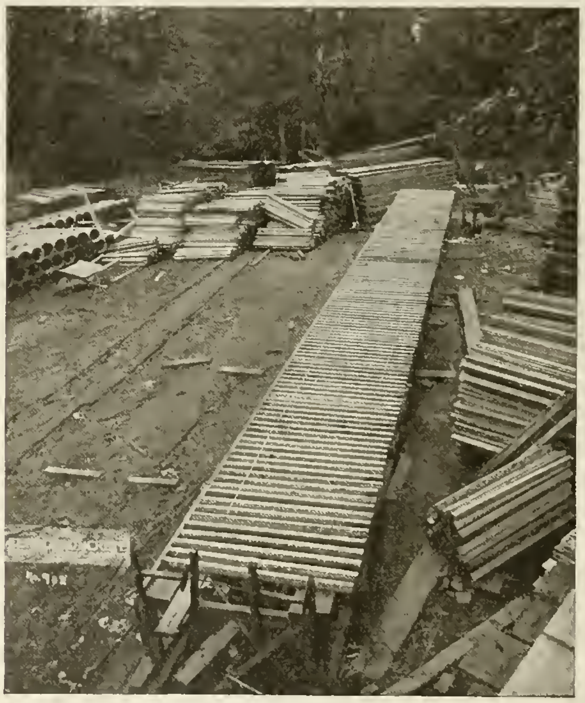
## SHRINKAGE OF WOOD BLOCK SHOP FLOORS.

Two recent instances of shrinkage of wood blocks in shop floors of the U. S. Navy Department have been partly remedied by pouring the joints with paving pitch. In the September Public Works of the Navy, Mr. E. R. Gayler, Civil Engineer, states that the paving pitch had the effect of holding the blocks in shape for ordinary conditions of traffic but where heavy loads were left in place for considerable periods of time the blocks gradually tilted and sunk out of place and then did not return to place after the removal of the loads, thus leaving the surface of the floor in an uneven condition. Mr. Gayler states that recent practice has been to use blocks 2½ in. deep for interior work where the ordinary depths for exterior work is 4 to 5½ in., and it is probable that the shallowness of the blocks used indoors had considerable bearing on their not maintaining a true surface.

At the Washington Navy Yard two small experimental sections were laid, one in which the blocks were bedded in 1-2 cement mortar and the joints poured with grout, and the other in which the concrete subbase was screeded true and coated with hot paving pitch and the blocks laid on the pitch without the use of a sand cushion, the joints being subsequently poured with paving pitch. Both of these experimental sections were very successful and of the two the latter form of construction appears to be, in general, the more desirable. It was found that with the shallow blocks there was no necessity for providing a cushion in so far as any irregularities in the depth of the blocks was concerned, as the depth of the blocks as furnished was quite uniform and might ordinarily be expected to be so.

## FLEXIBLE MAT SYSTEM OF CENTERING.

In building the East Side High School in Cincinnati, O., the contractors, The Ferro Concrete Construction Co., of Cincinnati, have succeeded in decreasing the cost of the formwork in a number of very ingenious ways. Among the new features of its methods is a new system for centering invented by one of its superintendents, Mr. Hodges. It consists of a series of flexible mats, formed of wide slabs about 4½ ft. long, spaced a short distance apart and fastened together by two flat, flexible chains or wires tacked to each rib about a foot from each end. The accompanying illustration shows some of these mats being made on the job, and also a number of mats already constructed, rolled up and stacked in piles.


Flexible Mats for Centering.

In using these mats, they are laid out on stringers placed about 4 ft. on centers, these stringers being shored up in the usual manner. Over the mats are placed sheets of No. 26 gauge galvanized iron "decking." This is tacked directly to the mats with small carpet tacks sufficient to hold it in place until the concrete is poured.

The advantage of this system lies, of course, in the ability to use these same materials over and over again. This means a big saving in lumber. There is also another advantage, that of a considerable saving in carpenters' time for building special forms. The mats are easily made and can usually be so lapped that very few special mats or formwork is required. The sheet metal seldom has to be cut and can usually be lapped as desired. After using, this metal is put through an ordinary hand roller to straighten out the bends and kinks. Likewise, the stringers do not have to be changed in length for different jobs, as they can usually be laid parallel to the beams in long lengths and lapped.

## THE ECONOMIC DESIGN OF PILE FOUNDATIONS.

Contributed by Charles E. Anderson, 37 Liberty Street, New York City.

Viewed from a standpoint of economy and efficiency in design, the subject of pile foundations is one which the authors seem to have passed over with but slight notice, very little of value having been written in this regard, and that little here and there in disjointed reference. There is much to be said, however, as to the methods to be employed in this class of design. While the methods to be used bear a close relation to ordinary spread foundation design, yet closer study reveals the fact that much money is buried in pile foundations, which intelligent design would have left in the bank. The average architect especially, and also the engineer to a large extent, has neither the time nor the inclination to thoroughly study out the best methods in a part of the design which is, to be sure, usually but a small part of the contract. On the other hand an understanding of the best methods can not be had by any means as readily from reference books as can those connected with steel design. An engineer's training fits him to be able to study out methods when he comes in contact with a new proposition. In this he is usually aided by the text-books. As far as the writer knows, however, there is no author who has treated pile foundations at all exhaustively. The most that the books do is to discuss the bearing power of various piles, give a few formulas and speak of getting the moments and designing your footing as a reinforced concrete beam. This sounds very simple, but to do it quickly, intelligently, or what is more, economically on a large job, is not so easy as it appears, especially to the engineer who does this kind of work only occasionally. There is nothing difficult nor complicated about the theory. It is only the boiling down of the methods, and putting them in workable form which presents, not particularly a difficulty, but a problem whose elements are time and practice.

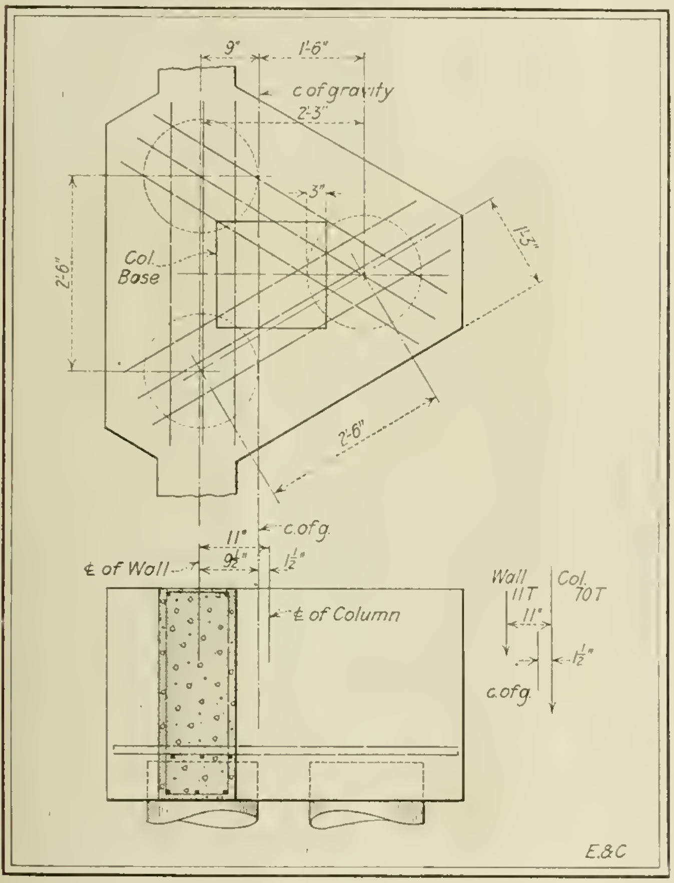


Fig. 1.

The following is an attempt, not by any means complete, to present some data on the subject, based upon practical work, the developed result of experience on many foundations. An attempt is made to reduce the formulas to the simplest form for use with the slide rule. Unnecessary refinement is eliminated and the work treated from a thoroughly practical viewpoint, that of the engineering contractor who knows enough about his subject to submit an alternative plan, which must fill the bill from an engineering point of view, as well as be the acme of economy.

Perhaps the simplest case is the support of an ordinary foundation wall. A common practice would be to place wood piles about three feet on centers under the wall, with a footing wide enough to cover the pile tops, carrying the foundation wall down far enough to keep the piles under water to prevent decay. It is quite likely that the piles will carry more than the load which rests upon them, as wood piles may be loaded up to twenty tons, according to the N. Y. Building Code. If the excavation required to reach permanent ground water level is considerable, concrete piles may be used, since they will last in dry ground, and may be driven from the surface, requiring very little excavation. Assuming that concrete piles are to be used, with an allowable load of 30 tons each, the problem resolves itself into the determination of how many piles are actually required to carry the load, grouping them in footings, and designing the foundation wall as a beam, strong enough to carry the wall load between footings.

Before taking an actual example, it would be profitable to discuss the formulas to be used in the design, putting them into practical shape for rapid design with the slide rule.

The fundamental formula in the design of a reinforced concrete beam, as recommended by the Joint Committee, is $bd^2 = \frac{M}{f_s pj}$, in which b is the breadth of beam, d its depth. M the bending moment in inch pounds, $f_s$ the allowable steel stress per square inch, p the percentage of steel to area of beam section, jd the resisting arm.

It is customary to use an allowable steel stress of 16,000 pounds per square inch, and an allowable compressive stress in the concrete of 650 pounds, for 1:2:4 concrete, the ratio of the moduli of elasticity of the two being n = 15. The economic ratio of steel for 1:2:4 concrete is .0077. For nearly all practical work j may be taken as $\frac{7}{8}$. If these values are substituted in the above formula the result will be

$$bd^2 \quad \frac{M}{107}, \text{ where M is in inch-pounds.}$$

It is much more convenient in using the slide rule to work in tons, doing away with the necessity of keeping track of the decimal points, and giving smaller figures to work with. Therefore, if we divide by 2,000 we get

$$bd^2 = \frac{M}{.054}, \text{ M being in inch-tons.}$$

Another formula is that giving the area of steel required:

$$A_s = \frac{M}{jdf_s}$$

If we substitute the same values as before, we get

$$A_s = \frac{M}{14{,}000d} \text{ (in inch-pounds),}$$

Or,

$$A_s = \frac{M}{7d} \text{ (in inch-tons).}$$

This formula is, however, more useful in another form, that which gives the steel stress instead of the area directly, for it is more convenient, knowing the stress to be resisted, to pick from tables the number of bars of a certain size which will resist the stress. Since the area times the allowable stress equals the total stress, we get

$$\text{Total Steel Stress} = \frac{16{,}000M}{14{,}000d} = \frac{8M}{7d}$$

Or in another way; we know that the bending moment divided by the resisting arm equals the stress, and since the resisting arm is $j = \frac{7}{8}d$, we have the stress equal to M divided by ⅞d, which gives the same result as before.

There is one difference between the usual design of concrete structures consisting mainly of beams and slabs, and the design of foundation beams. The same condition does occur in any type of design, but not to the same extent as in foundations. That is, in ordinary work it is customary whenever possible to assume the breadth of beam and compute the depth, using the economic ratio of steel, which for 1:2:4 concrete is .0077bd. In the design of foundation wall beams, however, the depth is usually the controlling factor, and the breadth is also generally controlled by the wall to be carried. It therefore becomes necessary to assume, or accept given dimensions for the beam, and find the proper ratio of steel, for the beam consists frequently of the wall for the full depth of the foundation below grade. On account of the long resisting arm in such a case, the steel area required is very small compared with that of a beam ordinarily designed to carry the same load.

In this connection, the ratio $R = \dfrac{M}{bd^2}$ is useful, in which $R = f_s pj$. This is the same formula as that first given, using the letter R to indicate $f_s pj$, R as there given being equal to 107. Knowing the depth and breadth of the beam we can substitute in the formula $R = \dfrac{M}{bd^2}$, getting a value for R. By substituting this in

$$R = f_s pj = 16{,}000p \times .87 \text{ gives a value for p.}$$

The actual value of j varies slightly from ⅞ or .87, namely from about .85 with p = .011 to about .91 when p equals .003. These variations make very little difference in the practical results, and may be disregarded for practical purposes. The following table gives values of R for n equals 15, with corresponding values of p:

TABLE I.

| $f_s = 16{,}000$ <br> $f_c = 650$ } n = 15 | | $f_s = 16{,}000$ <br> $f_c = 650$ } n = 15 | |
|---|---|---|---|
| p. | R. | p. | R. |
| .001 | 15.15 | .011 | 120.34 |
| .002 | 29.69 | .012 | 123.50 |
| .003 | 43.87 | .013 | 126.40 |
| .004 | 57.78 | .014 | 129.10 |
| .005 | 71.48 | .015 | 131.60 |
| .006 | 85.00 | .016 | 133.94 |
| .007 | 98.37 | .017 | 136.13 |
| .00769 | 107.53 | .018 | 138.19 |
| .008 | 108.92 | .019 | 140.13 |
| .009 | 113.11 | .020 | 141.96 |
| .010 | 116.90 | | |

For example, let it be required to find the percentage of steel required to resist a moment of 700,000 inch-pounds in a foundation wall beam in which b equals 16″, d equals 60″. We get $d^2 = 3600$, $bd^2 = 57{,}600$. Substituting these values in $bd^2 = \dfrac{M}{16{,}000p.87}$, we get p = .0009, or using the table, $R = \dfrac{M}{bd^2}$ gives R equals $\dfrac{700{,}000}{57{,}600} = 12$. The lowest value of R given in the table is 15.15, which gives p = .001 which is close enough. It will be seen that a deep beam requires very little steel, pbd in this case being only .86 square inches, using p = .0009, or about one square inch, for which four ¼ inch bars could be used.

The amount of steel required can also be determined by another method, using the formula

$$A_s = \frac{M}{7d} \text{ in which M is in inch-tons.}$$

In this case, M equals 700,000 divided by 2,000 or 350 inch-tons, and d equals 60 inches. Substituting in the formula we have $A_s = \dfrac{350}{7 \times 60} = .83$ square inches, which agrees quite closely with the other method. This formula is generally more useful in its other form:

$$\text{Stress} = 8M/7d = 8 \times 350/7 \times 60 = 6.67 \text{ tons.}$$

We can now take directly from Table II the bars which will supply steel enough to resist this stress, the table being applicable for steel having an allowable stress of either 16,000 or 20,000 pounds per square inch, or 8 tons or 10 tons. From the table we see at a glance that three ⅝″ round bars will take a stress of 3 × 3.45 or 7.35 tons or if we prefer to use square steel we note that two ⅝″ and one ⅜″ bars will take a stress of 2 × 3.13 + 1.13 = 7.39 tons.

TABLE II.

| | | Stress | | | Stress | |
|---|---|---|---|---|---|---|
| Size. | Wt | 8-ton. | 10-ton. | Wt. | 8-ton. | 10-ton. |
| ¼-in. | .212 | .50 | .63 | .167 | .39 | .50 |
| ⅜-in. | .478 | 1.13 | 1.41 | .375 | .89 | 1.10 |
| ½-in. | .850 | 2.05 | 2.50 | .667 | 1.57 | 1.96 |
| ⅝-in. | 1.328 | 3.13 | 3.91 | 1.043 | 2.45 | 3.07 |
| ¾-in. | 1.913 | 4.50 | 5.63 | 1.502 | 3.53 | 4.42 |
| ⅞-in. | 2.603 | 6.13 | 7.66 | 2.044 | 4.86 | 6.01 |
| 1 -in. | 3.400 | 8.00 | 10.00 | 2.670 | 6.28 | 7.85 |
| 1⅛-in. | 4.300 | 10.13 | 12.65 | 3.379 | 7.95 | 9.94 |
| 1¼-in. | 5.310 | 12.50 | 15.67 | 4.173 | 9.81 | 12.27 |
| 1⅜-in. | 6.428 | 15.13 | 18.91 | 5.049 | 11.89 | 14.85 |
| 1½-in. | 7.650 | 18.00 | 22.50 | 6.008 | 11.13 | 17.67 |

Note.—Area of bar equals the stress given for 10-ton steel, divided by 10—i. e., area of ½-in. square bar = 2.50 ÷ 10 = .25 sq. in.

It is necessary to reinforce the top of the beam somewhat for possible negative moment. A good plan is to use a moment of WL/8 for the positive bending moment and use 6/10 as much steel in the top. This is a rule given by Hoole, and works out well. If a moment of WL/12 is used, correct design requires the beam to be designed for an equal negative moment. If, however, WL/8 is used, the steel in the bottom may be assumed as having some effect in resisting the negative moment, thereby justifying a somewhat smaller amount in the top than would be required by WL/12, which is the usual moment for a continuous beam in intermediate spans.

A beam of this sort should be examined as to the necessity of web reinforcement, and even though none may be required, it is good practice to place stirrups or hoops of say ¼″ around rods at intervals not exceeding ¾ the depth of beam.

The spacing of hoops may be determined in the usual way for beams.

The formula for spacing of web reinforcement, i. e., stirrups or hoops is $S = 3a_s f_s jd/2V$ in which S is the distance center to center of hoops or stirrups (for vertical stirrups), $a_s$ is the area of steel in the stirrup, V the shear. It is most convenient to assume the size of steel to be used and compute S. Steel used for stirrups or hoops is usually either ¼″ round, ⅜″ round or ½″ square, although any other sizes may be used if desired. Working on the premises that we shall generally use these sizes, and that for ease in placing we are going to use vertical hoops as a rule, why not have these sizes incorporated into a formula, using a constant for each size steel. For instance, the area of a ¼″ round bar is practically .05 square inches, the effective area in a hoop being twice that. Using this value and the customary practical values for the other constants, we have, substituting in the formula

$$S = \frac{3 \times 2 \times .05 \times 16000 \times 7/8d}{2V \text{ (in pounds)}} = \frac{2100d}{V \text{ (in lbs.)}} = \frac{d}{V \text{ (in tons)}}, \text{ practically,}$$

which is a simple slide rule formula for finding the necessary maximum spacing for ¼″ round hoops at any point in the beam, V being the shear at that point.

In a similar manner, we get for ⅜″ round hoops or stirrups

$$S = 4620d/V, \text{ in pounds, or}$$

$$S = \frac{2.31d}{V \text{ (in tons)}}$$

For ½″ round hoops,

$$S = 7400d/V;\ S = \frac{3.7d}{V \text{ (in tons)}}$$

For ½″ square hoops,

$$S = 10500d/V;\ S = \frac{5.25d}{V \text{ (in tons)}}$$

To illustrate a somewhat different problem in which the same principles are involved, let us assume a building having columns spaced 25 feet center to center with spandrel walls between. The center of gravity of the wall is 11 inches outside the center of columns. Wall is a nine inch wall weighing for the whole span, 22,000 pounds. Column loads are 70 tons on each column. The first question is, how many piles are required? If we are going to use concrete piles with a bearing capacity of 30 tons each, we require enough to carry 11 tons plus 70 tons plus the probable weight of the beam necessary to carry the wall, say 6 tons, total 87 tons. This would take three piles. The beam will have to carry the wall, and its own probable weight, total 17 tons. The beam is continuous, but there is a probability that it will not all be placed at once, so to be on the same side we shall design it as a simply supported beam, using

$M = WL/8.$

$M = 17T \times 23' \times 12''/8 = 586''T$

$bd^2 = M/.054 = 586/.054 = 10,800$

$b = 12''$ (assumed) $d^2 = 900$, $d = 30''$.

Steel stress $= 8M/7d = 8 \times 586/7 \times 30 = 23T.$

Use 3⅞" bars, (from Table II).

Since we used WL/8 for positive moment, we need use only .6 as much steel over supports for negative moment. .6 × 23T = 13.8T resisting strength of steel over supports required. Use two ¾" bars, and bend up one of the bottom bars at about the third point of span.

TABLE III.

| 18-in. pile. Areas of segments. Altitude. | Per cent. | 18-in. pile. Areas of segments. Altitude. | Per cent. |
|---|---|---|---|
| 1.0-in. | 2.2 | 5.5-in | 25.9 |
| 1.5-in. | 4.0 | 6.0-in. | 29.1 |
| 2.0-in. | 6.1 | 6.5-in. | 32.5 |
| 2.5-in. | 8.4 | 7.0-in. | 36.0 |
| 3.0-in. | 10.6 | 7.5-in. | 39.4 |
| 3.5-in. | 13.6 | 8.0-in. | 43.0 |
| 4.0-in. | 16.5 | 8.5-in. | 46.4 |
| 4.5-in. | 19.4 | 9.0-in. | 50.0 |
| 5.0-in. | 22.7 | | |

It is now necessary to try the beam for diagonal tension. The Shear V will be equal to half of the total load or 8.5 tons, say 9 tons. For ½" square hoops the formula is $S = 5.25d/V = 5.25 \times 30/9 = 17''$. For convenience in spacing we would place the hoops 16" apart. Some designers would prefer to vary the spacing, increasing the distance toward the center of the span, but the hoops are usually so small a percentage of the total steel that it is well to space them evenly for the full length of beam, avoiding any possibility of error in the field.

This design is not complete until we find the center of gravity of the pile bearing power and place it under the center of gravity of the loads. Since the loads are the wall load of 11 tons and the column load of 70 tons, the sum being 81 tons, and the distance between the loads 11", the center of gravity of the loads will be nearer the heavier load and will be 11/81 of 11", or 1½" from the column center. The footing will then look somewhat as in Fig. 1.

The depth of the footing in this case depends upon the depth of the beam. It is evident that this depth is enough to resist the shear due to the column load. The area of concrete which will resist shear is a section under each of the four sides of the column base. If the column base is 17" the section resisting shear will then be 4 × 17" × 30", 30" being the depth d, or equals 2,040 sq. ins. It will be noted that one of the piles projects 3" under the column base. This segment is 10% of the total area of one pile, and this much of one pile load should be deducted from the column load to get the shear load. Each of the three piles carries one-third of the column load of 70 tons, or 23.3 tons. Deducting ten per cent of 23.3 from 70 tons we get a shear load of 67.7 tons due to the column load. Dividing this in pounds by the area 2,040 sq. ins. we get the unit shear equals 69 pounds per square inch, which is safe, 120 pounds being allowable for reinforced concrete.

The footing must be reinforced to resist the moment due to the column load. The column moment will be $70T \times 17''/8 = 149$ inch-tons. The pile moment is $23.3T \times 15'' = 450$ inch-tons, which deducted from the column moment leaves a bending moment of 301 inch-tons. A conservative method of figuring footings is to consider that the load is distributed downward and outward at an angle of 22.5 degrees from the vertical. This would give a width of beam to be considered in designing the steel, of w plus d, in which w is the length of the base plate in the direction of the moment, and d the depth of footing. This would give us a width b of 17 plus 30 or 47 inches. From the formula $R = M/bd^2$ we get $R = 301 \times 2,000/47 \times 30 \times 30 = 15$. From the table we get, for $R = 15$, $p = .001$. Knowing that $bd = 47 \times 30 = 1,410$, we get $A_s = .001 \times 1,410 = 1.4$ sq. ins. From Table II we fine that three ¾" bars will give this area.

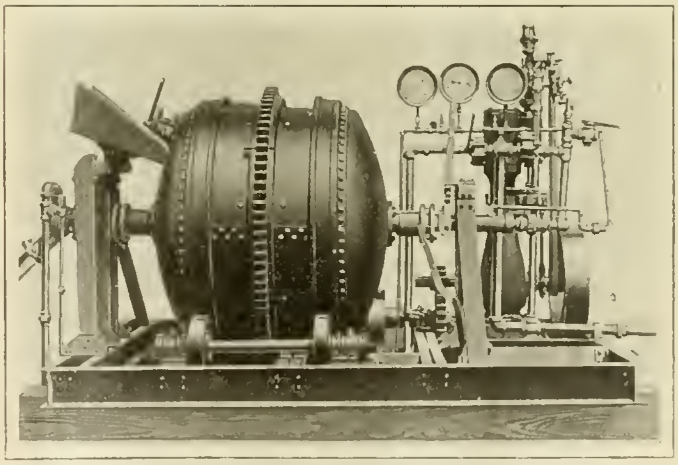
A similar procedure is necessary in designing the footing under a column for any number of piles. Where the depth is not otherwise controlled it is necessary to compute the necessary depth to resist shear, reinforcing for shear if necessary, considering diagonal tension, as in a beam. The areas of portions of piles which project under base plate must have their bearing capacity deducted from the column load to get the shear load. Table III will be of assistance in this respect, giving the percentage of the area included in segments of various heights for piles of 18" diameter. The pile moments for all other piles must be computed and the column moment deducted to get the bending moment, in each direction. A subsequent article will give the design of a footing having a larger number of piles, under a heavy column load, and also a method of designing a cantilever footing.

## NEW FORM OF PNEUMATIC CONCRETE MIXING MACHINE.

(Contributed.)

The new pneumatic mixer, conveyor and placer illustrated consists essentially of a cylindrical drum mounted on a horizontal axis driven by an independent engine or motor and contains mechanical mixing apparatus and special appliances for delivering the mixed concrete to the outlet through which it is forced by pneumatic pressure without stopping the revolutions of the machine. After a batch is discharged, the machine is stopped, recharged through the hopper and the process continued with regularity and rapidity.

The hollow trunnion outlet may be connected to a pipe from 2 to 8 in. in diameter, through which the concrete is discharged in a continuous steady stream at a velocity of about 50 ft. per second, with an air pressure of only 15 to 20 lb. per square inch. This pressure is maintained steadily and uniformly and is free from the fluctuations of from 5 to 40 lb. that have obtained in pneumatic distributing machines. The steady output of concrete doubles the capacity of the machine and reduces the amount of compressed air by about 50 per cent per cubic yard of concrete placed. A feature of the machine is its ability to discharge concrete made with 1-in. stone through a 2-in. pipe. 1½-in. stone concrete can be discharged through a 3-in. pipe, 2-in. stone concrete through a 4-in. pipe, and concrete made with a run of crusher stone through a 6-in. pipe.



New Form of Pneumatic Concrete Mixer.

Machines fitted with 2 or 3-in. discharge pipes distribute the concrete to a total horizontal distance of about 500 ft.

and a vertical height of 90 ft., while the larger sizes, with from 4 to 8-in. discharge pipes can place it 3,000 ft. away horizontally and 100 ft. high.

The machines are operated by a single man, exclusive of those supplying material, and up to and including 4-in. discharge pipe, have a capacity of from 20 to 50 yd. of concrete mixed and placed in 8 hr.

The discharge pipe terminates with a rubber hose of the same diameter which for the smaller machines can easily be handled by one man and operated easily without any kick in the pipe. The hose is, of course, eventually worn out by the concrete, but its life depends largely on the quality of the rubber lining and has been found to be as great as 4,000 yd. of concrete for an 8-in. pipe. A machine proportioned for a 2-bag batch of concrete and having a 3-in. outlet can discharge in 10 sec. against 20 sec. required for the same amount of concrete mixed in the old machine with an 8-in. outlet.

The large new machine has a capacity of about 500 yd. of concrete in 8 hr. when conditions are favorable. A 2-bag machine, 3-in. outlet, weighs complete about 8,000 lb. and is operated by an 8-hp. engine or motor. The best results are obtained at a speed of about 16 r. p. m. and concrete of any degree of consistency can be handled successfully with it. Enough water to prevent it from sticking to a wheelbarrow when the latter is dumped is recommended.

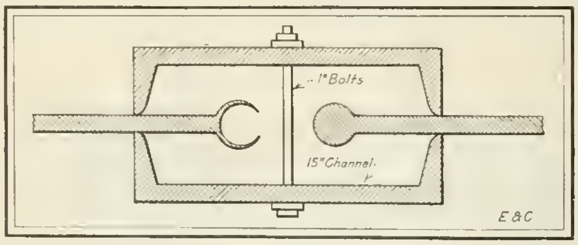
The machines are placed on the market by the Pneumatic Placing Co., Inc., 2 Rector St., New York.

## METHOD OF MAKING CLOSURE IN STEEL SHEET PILING.

Contributed by S. A. Swanson, State Bridge Inspector, Butte, Nebraska.

The following method of closing the wall of a steel cofferdam in a Missouri River job in Omaha was used with marked success and has been equally successful on a number of smaller jobs.

Two 15-in. channels were bolted together, flange to flange, as shown in diagram, and driven with flanges fitting snugly against the webs of the sheet piles. As each bolt reached the water line it was tightened, and a wedge-shaped opening 32 ft. in depth and tapering from 13 in. at the bottom to practically nothing on top, was closed and a water tight joint made by this method. The piles were driven into bedrock and it was at first attempted to close the dam by driving a key pile, but this pile was torn out at a depth of about 15 ft. Mr. J. N. Johndreau, at that time superintendent for the Western Bridge and Construction Co. of Omaha, was responsible for the idea.



Closure Joint for Steel Sheeting.

## A 1,300-FT. LONG DAM IN NEW ENGLAND.

A meeting of the manufacturers of the Naugatuck Valley, Connecticut, has been held to take further action toward the development of a reservoir for impounding the water of Lead Mine Brook. The complete project calls for the construction of three large dams. The first dam, as proposed, would be 1,300 ft. long and 142 ft. high, and would contain several hundred thousand cubic yards of cyclopean masonry. The plan calls for the storage of water during the winter months and its release about July 1. This would greatly increase the amount of water power down the Naugatuck Valley; would cleanse the Naugatuck River and bring it into a much more sanitary condition and would be a great benefit to each city and town along the river as far south as Derby. Charles H. Preston, Waterbury, Conn., is the Engineer for the manufacturers.

## NEWS LETTERS.

### St. Louis Items.

The L. J. Smith Construction Company have sublet all of their bank widening work on the Missouri, Kansas & Texas R. R. in Oklahoma. L. J. Smith has been cleaning up at all the big stock shows in the West lately with his white face cattle.

V. E. Steen has been sick in Kansas City all summer, but reported the other day that he expected to be out on some work again before long.

Roger Faubion of the J. W. McMurray Contracting Co. passed through St. Louis the other day on his way to Cape Girardeau to renew work on their concrete job for the Frisco R. R. Co. The high water last year caused them to shut down.

J. J. Purcell writes from Annada, Mont., that he has a drag line and a western grader idle at that point.

McArthur Bros. Co., Vincennes, Ind., have 100,000 yards of good levee work to let at that point. They will let this work in quantities to suit outfit. Prices will be arranged after parties look over the work

The J. W. McMurray Contracting Co. of Kansas City were awarded the contract for building two new bridges for the M., K. & T. R. R. near Shawnee and Oklahoma City, Okla. They also were awarded the contract for building the temporary approach for the Twenty-third street viaduct, Kansas City, Mo.

Prosecuting Attorney Richard F. Ralph of St. Louis County instructed the court to issue $520,000 road bonds under the recently adopted $3,000,000 bonds issue. Of this amount $10,000 worth is in denominations of $100, the balance $1,000. Ralph had conferred with Assistant Attorney General W. T. Rutherford, and it was agreed that the Attorney General's office will advise the State Auditor to accept the issue. Ralph said that he desires to prove that bonds of $100 denomination are not as readily salable as those of the larger denominations. The court also instructed Collector Albert Wilmas to add 5 cents per $100 valuation on the 1916 tax bills due for payment in September. The court will shortly advertise for bids on work to be done with the recently issued bonds.

Pete McEnroe, Hotel Georgian, Henryetta, Okla., will have his 30-team outfit idle at that point in a few days, is in the market for some more grading.

J. D. Vogt of Belleville, Ill., was awarded the contract for county road work near there last week.

P. J. Murphy, of Moberly, Mo., secured a bridge filling job from the Wabash R. R. Co. near Conception, Mo.

A. Burk has seven teams idle at Ridge Farm, Ill.

Thomas J. Dolan of Chicago spent a week here visiting contractors. Dolan reports doing an elegant business here during his stay.

The Heman Construction Co., Title Guaranty building, St. Louis, have 130,000 yards of work in southern Illinois to sublet. Grant Wyatt of this company will be pleased to show contractors over the work.

"Pretty Good Luck" Dave Griffiths is in Kansas City at the present time. Expects to go back on his big ranch in the west in a couple of weeks.

Webb-Kunze Construction Co. are excavating for the foundation of the new Bevo plant that is going to be erected here by the Anheuser-Busch Brewing Co.

The Iron Mountain R. R. Co. is going to erect a new depot at Bismark, Mo. Are also contemplating erecting a round house and coal chute there.

A. B. Koenig and family spent the past two weeks in the west. Returned to St. Louis last Monday feeling better than ever.

The Board of Public Service on September 12 granted permits to the Terminal Railroad Association to lay tracks across seven streets in the north end of the city and east of Broadway, in a district bounded by Prescott, Bulwer, Luther and Taylor avenues. The tracks will be laid on a tract recently purchased for a storage yard to be used in connection with the Terminal's west belt line. The streets over which the tracks will be laid for a block are Pitzman, Newman, Sweringer, Campbell, Morin, Taylor avenue, and a half block on Gypsy street. No protest has been made against the issuance of the permits. A. B. KOENIG.

## PERSONALS.

W. J. Fournier has been appointed assistant engineer of the Coast Lines of the Santa Fe System, with headquarters at Needles, Cal., succeeding B. H. Quinham, resigned.

Oliver W. Connet has been appointed valuation engineer of the Western Maryland R. R. Mr. Connet until recently was connected with the City Engineer's Department of Baltimore, Md.

George C Andrews has been appointed supervising engineer of the water works of Buffalo, N. Y. He formerly was resident engineer of the New York State Barge Canal at Lockport, N. Y.

Charles Scott Landers, Reuben Davis and Alan M. Ferebee have organized the Substructure Co., Inc., with offices at 115 Broadway, New York City, and will specialize in foundation and underpinning work.

Harold E. Ketchum has been made vice-president of the Graff Construction Co., Seattle, Wash. Mr. Ketchum formerly was connected with the Hunkey-Conkey Construction Co. and was superintendent for the company during the erection of the Detroit-Superior bridge at Cleveland.

A commission of eight engineers and a physician have been appointed by the City Council of Chicago, Ill., to study out a method for preventing future epidemics of typhoid fever in that city. The commission consists of Isham Randolph, George E. Earl, Lyman E. Cooley and Langdon Pearce of the Sanitary District, W. A. Nelson and W. R. Matthews of the Bureau of Sewers, Cicero D. Hill of the Board of Local Improvements, Frank R. Sadler, chief engineer of the Sixty-eighth Street Pumping Station, and Dr. Herman N. Bundesen of the Health Department.

H. A. Lane has been promoted from assistant engineer of surveys to assistant to the chief engineer of the Baltimore & Ohio System. Mr. Lane's engineering experience began in 1895 as a rodman on the engineering corps of the New York, New Haven & Hartford Railroad, and in 1901 he was made assistant engineer in charge of the northern half of improvements for the abolition of grade crossings at Fall River, Mass., a work costing $1,600,000. In December, 1902, Mr. Lane entered the employ of the Baltimore & Ohio in the office of the assistant engineer of surveys. In 1907, when the Baltimore & Ohio R. R. began its campaign for the betterment of its line, Mr. Lane was given charge of operations for freight terminal betterments. He was made assistant engineer of surveys in 1910, in which capacity he remained until his recent promotion.

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## QUERY TO CANADIAN ENGINEERS.

The theory of "protection to home industries" has been carried by many American cities to the absurd extreme of restricting appointments of city engineers and other employes to residents of the city. We have always opposed the building of a professional Chinese wall of this character. We regret therefore that the council of the Canadian Society of Civil Engineers has seen fit to advocate a Chinese wall around Canada.

Prof. George F. Swain, of Harvard, was recently selected by a Canadian commission that is to investigate the railway situation in Canada. Prof. Swain is to have charge of the appraisal work, and it is against this appointment of "an outside engineer" that the council of the Canadian Society of Civil Engineers protests.

We have believed in the licensing of civil engineers, which the Canadian Society has brought about, and we admire the political activity of this society, but isn't it stretching self-interest somewhat beyond the elastic limit when any society urges that one of its own members, even though a foreigner, be excluded from engineering practice within the domain of the society?

The members of the Canadian Society are asked to write to their representatives in the Dominion Parliament and otherwise to bring political pressure to bear in an effort to prevent, at least in future, the employment of American or other foreign engineers as chiefs on public work in Canada. If we mistake not, more engineers of Canadian birth and education have found employment in America than the converse. Indeed, we welcome good engineers from whatsoever country. Sorrowfully now do we note this recent action that may lead to reprisals in a field where fraternity should prevail.

## LOCATING ROADS WITH REFERENCE TO MAINTENANCE.

The highway engineer who has had experience in the maintenance of way department of a railway through hilly country frequently avoids road location that seems entirely satisfactory to an engineer lacking such experience. Thus, drifting snow is one of the railway maintenance bete noires. Long shallow cuts exposed to sweeping winds are particularly hard to keep clear of snow. In general, the greater the percentage of embankment the less will be the snow trouble.

Sidehill springs, often dried up in summer when a road is located, are a source of maintenance expense, where they flow into a sidehill cut. The location of such wet spots is generally indicated by the character or profuseness of the vegetation. Hence a highway engineer should have an eye for changes in vegetation along any proposed route.

High embankments settle for years after building. On a side hill an embankment settles more on its outer, or deeper, side than on its inner side. Hence a concrete pavement on a sidehill fill is exceedingly apt to crack and to continue cracking if the concrete is laid soon after the fill has been made.

In his "Economics of Road Construction," the editor called attention, many years ago, to the importance of locating a road on porous soil where this is possible without greatly increasing construction costs. Clay soil, when wet from rain and melting snow, often yields under heavy loads even where the pavement is 6 in. thick. Heavy motor trucks, therefore, are apt to cause disintegration of a road built on a clay that becomes saturated with water. Let it not be supposed that deep side ditches will always remove this risk, for where snow accumulates in the ditches, water runs off very slowly and much of it finds its way under the pavement.

Changing the course of a small stream is often resorted to in an effort to reduce the cost of bridges. Be careful, when this is done, not to steepen the hydraulic grade of the stream, for the resulting swifter current will cut away the banks of the stream until the original hydraulic grade is again established. The editor made this mistake once. Even riprap would not hold the creek to the new and shorter channel that had been dug for it.

## A MOVABLE PLANK ROAD CARPETED WITH ASPHALTIC OIL AND SAND.

The engineers of the California Highway Commission have again proved their resourcefulness. Confronted with building six miles of road through shifting desert sands between Yuma, Ariz., and Holtville, Calif., it was decided to lay a plank roadway 8 ft. wide, with turnouts every 1,000 ft., and to put a ¼-in. wearing coat of asphaltic oil and sand on the plank.

The unique feature of this construction was the building of the road in units 12 ft. long, which were loaded on wagons and unloaded and placed with tackle suspended from a movable frame very much like a bridge "traveler." Planks, 4x12 in. x 8 ft., were spiked to three lines of 4x6-in. stringers, forming a section 12 ft. long. Strap iron was then bolted down over the spikes to prevent their working loose.

The road was built in 4 months at a cost of about $8,500 per mile. In the event that the drifting mounds of desert sand interfere with traffic, it will be possible to shift parts of the road to new locations.

Many of the plank floors of highway trestles and bridges in California have been carpeted with asphaltic oil and sand, and the carpet has proved to be a decided protection to the plank. But this use of such a carpet on several miles of plank road is, we believe, without precedent.

## THE CATERPILLAR TRACTOR BECOMES A "TANK."

Except the flying machines no mechanical device in the great war has excited as much editorial comment as the "tanks" or "land warships." In the first newspaper descriptions of these new engines of war, American engineers and contractors recognized old friends in new garbs. The caterpillar tractor had put on a coat of mail, and, "armed to the teeth," had lumbered forth onto the battlefield to shoot and be shot. In plain, the English had converted a particular type of American traction engine into an armored car which is capable of traveling over soft and irregular ground because it continuously lays and picks up its own track.

The editor recalls seeing a caterpillar or apron wheels in use on a ditching machine about 14 years ago. He was told that the device was at that time several years old. The caterpillar tractor, made by the Holt Mfg. Co., of Stockton, Cal., was used for hauling gang plows and other farm machinery. Later it was used for hauling trains of wagons on construction work, notably on the Los Angeles aqueduct. Now the caterpillar tractor is catipulted into world-wide prominence by its peculiar use in the war.

About 1,000 of these tractors have been sold to the Allies by the Holt Mfg. Co., of Peoria, Ill., presumably for use in hauling guns and wagon trains. Now it appears that the English have ingeniously turned some of them to other uses, and it may very well transpire that the new "tank" may effect as marked a revolution in methods of land warfare as was effected in naval warfare by Erickson's "cheese box on a raft"—the Monitor. At any rate we have new evidence that warfare is more and more a contest between engines.

Next we may hear of fleets of American trench diggers, likewise mounted on caterpillars as some now are, following fleets of "tanks" and digging shelter trenches before the infantry advances to occupy them. Why not?

From a great number of daily paper editorials on the "tank," we select one from the New York "Post" for reprint. Under the title, "New Honors for the Mule," appeared the following:

> So it turns out that the latest military novelty is the American mechanical mule, fitted with tortoise armor to protect his vitals and carrying machine guns—doubtless of the Lewis type, not good enough to be adopted by our ordnance board. The machine that leans against a brick wall and flattens it, snaps trees as if they were twigs, takes ditches like a kangaroo, and waddles along in an unstoppable way, comes from Peoria, Ill., and has been on the market for a number of years.
>
> In August, at Fremont, Neb., was a grand mobilization and review of farm tractors. Forty-eight different manufacturers were represented by cars of as many different types. They deployed in the presence of 50,000 critical farmers, showing what they could do in the way of gashing Mother Earth, pulling up stumps, and hauling huge loads. There were caterpillar behemoths of the kind that have created a sensation on the Somme, and the little Henry Ford, looking like a laundry delivery wagon.
>
> There is high authority for the declaration that it was not soldiers or cannon that won at Appomattox, but the tireless and blameless mule. It may turn out that the mule's mechanical derivative will bring to an end the war in Europe. In the warfare of positions the defense has had an advantage for two years, but of what use are trenches and embankments if an untouchable steel beast, spitting bullets like water from a hole, and perforating what he does not flatten, is able to romp over them, cutting wire entanglements as he noses along? Are wars of the future to be between land battleships? Is victory to come to the Allies simply because Winston Churchill had imagination enough to see first the use that could be made of caterpillar traction, and thus in one thing prepared ahead of the Germans?
>
> The aeroplane has been a success—is now indispensable to military success. The big siege gun has made archaic all forms of fortresses. On the other hands, the heavier-than-air airship, except for observation purposes, has thus far been a military failure. The gas attack, despite its dreadfulness and the terror it first aroused, seems to have been provided against. Nor has anything decisive come from the use of the flame ejectors on which the Germans built such great hopes. It may be that the armored tank will turn out to be merely another novelty. Nevertheless, it seems to have proved most effective on the first trial. It would seem as if some factor has been introduced to soften the stiff German line. One can imagine the hurried consultations that are going on among German engineers and the feverish haste of German factories as they work to create squadrons of the new dinosaurs.

## CHANGE ASSESSMENT METHODS IF YOU WOULD GREATLY IMPROVE CITY STREETS.

Farm produce delivered at city residences costs the consumers two to three times what the farmer receives for it. A very considerable part of the "middleman's profit" is actually not profit but the expense of delivering the produce over bad city pavements. This expense seems likely to decrease with increased use of auto-trucks and auto-delivery wagons, but the decrease will not be what it should be until such time as practically all the streets in cities are smoothly paved.

On the whole, city pavements are yet far from being satisfactory roadways for delivery vehicles and trucks moving at speeds of 15 miles an hour or more. Even for horse-drawn wagons most pavements leave a great deal to be desired, but as trackways for motor cars—well, ask the merchant who has to maintain the cars what rough streets mean to his pocketbook.

Before there is apt to be much improvement effected in city pavements there must be revision of laws governing assessments for street construction and repair. In many cities the entire cost of a new pavement is levied against the abutting property owners. This relic of municipal antedeluvianism needs the attention of all city engineers who have the best interest of their cities at heart. They may well call public attention to the fact that no great progress was made in country road improvement until the states began to bear a large part of the cost of roadwork. Similarly the city at large should bear fully half, and probably two-thirds, the cost of street construction and reconstruction.

City engineers will do well to study all ordinances that govern assessments for municipal works, with a view to taking the lead in effecting desirable changes. If left to itself the public will seldom change anything. Let a poor law be enacted, and, unless it directly hurts some individual, it stands fair chance of existing forever. An ordinance may indirectly hurt every citizen in the town, yet none but a very few may realize the seriousness of the injury. Among those few is the city engineer, and upon him devolves the duty of arousing public opinion to the point where remedial action will be taken.

In these days of altitudinous prices for foods of all kinds, the public will lend a willing ear to methods of reducing the prices. We suggest, therefore, that engineers engage public attention by showing the economic possibilities that lie not only in having good roads radiating from every town but good roads within every town and in every part of the town.

## DOUBLE-TRACKING ROADS ON CURVES.

Many automobile accidents on sharp curves are due to the tendency of drivers to run on the outer side of the curves regardless of the direction they are traveling. Engineers of the Minnesota Highway Commission prevent this tendency by double-tracking roads on sharp curves. This is accomplished by grading a crescent shaped bank in the middle of the road on curves, thus splitting the highway into two separate roadways.

In previous editorials we have advocated the widening of roads on curves, and the clearing away of vegetation that obstructs the view of drivers. At the recent Conference in Highway Engineering at Kansas State Agricultural College, Mr. H. E. Bilger, engineer of the Illinois Highway Commission, urged the desirability of acquiring an extra width of right of way on sharp curves. The inner right of way face can then be set back and the curve flattened.

## EDITORIAL COMMENT.

A new road over the Continental Divide, Wolf Creek Pass, in Southwestern Colorado, was opened for traffic last month. It shortens the route to Southern California by 300 miles. The 30 miles of this road cost $3,000 a mile. A part of the road was surfaced with disintegrated granite. The ruling grade is 6.5 per cent, and the sharpest curves have a 30-ft. radius, around which a large automobile can turn readily.

Contrary to general opinion few engineering graduates leave the profession. Of 23,000 men who graduated from engineering colleges during the years 1901 to 1914, only 10 per cent reported as having gone into pursuits not classed as engineering, according to an investigation made by Prof. A. A. Potter of the Kansas State Agricultural College.

Thin brick pavements, now that they have at last "arrived," are likely to become increasingly popular. The so-called "vertical fiber" paving block has two wearing faces, 4x8½ in., that are wire cut. The sides have lugs. These blocks may be had in four different thicknesses, 2½, 3, 3½ and 4 in., the 3-in. thickness being at present most popular for streets of medium and heavy traffic. For a square yard 32 to 35 blocks are required. As previously noted in these columns, 16,000 sq. yd. of brick 3 in. thick on concrete, were laid in Kansas City in 1914. Asphalt joint filler and an asphalt "carpet" (liquid asphalt sprinkled with sand) preserve the bricks from wear and reduce the noise. The "carpet," if made of good asphalt, lasts one to three years under moderate to heavy traffic.

## WHY NOT AN AMERICAN STANDARD ROAD?

To the Editor: While in Washington in response to the invitation of the Office of Public Roads and Rural Engineering to discuss the Federal Aid Road Act, the Association of State Highway Commissioners of the United States, whose membership had larger representation than upon any previous occasion, held a special meeting on Aug. 15, when a resolution regarded by the Association as extremely important was adopted. It provided for the appointment of a special committee to act in conjunction with the Office of Public Roads and Rural Engineering in the formation of a complete and up-to-date set of standard plans, specifications and forms for the construction and maintenance of Federal aid roads, and the committee was given full power to act without reserve. The resolutions had the full support of the Bureau of Public Roads, and was unanimously adopted.

The foregoing facts are referred to at length because they give emphasis to the imperative necessity of thorough standardization in the construction of all Federal aid roads if these roads are to represent uniform results in the way of durability, economy and satisfactory service.

The query at once arises as to whether the purpose to effect the standardization described could not be extended in principle far beyond the jurisdiction of the Federal Government through its adoption by State and County authorities and by engineering public opinion. And even more important, could it not be carried to a point that would result in the adoption of what might be termed a national or standard highway as opposed to our present miscellaneous, costly and unsatisfactory types of roads?

If there should be evolved or adopted an American standard road, what should be its type?

By discarding types of highways whose initial cost is beyond the resources of the average community, and likewise roads conceded to be obsolete from the viewpoint of durability and economy, two types remain. They are the bituminous road and the Portland cement concrete road.

It has been found by practical experience extending over a period of years that these two roads can be advantageously combined. For example, highway engineers are constantly emphasizing the importance of firm and unyielding foundations for roads, it being conceded that lacking in this respect no type of road will endure. No material is better adapted to foundation purposes than concrete. Confined to this function it can be laid more rapidly and at lower cost than in the case of all-concrete roads. Given a 2-in. wearing surface of asphalt macadam the concrete is protected from sudden and extreme changes in temperature, and, still more important, the water shedding surface serves to keep the moisture content of the concrete more constant than where concrete is carried to an exposed wearing surface. It is pretty generally conceded that saturation and subsequent drying of concrete road slabs are responsible for cracks, disintegration and upheaval. Where concrete is covered with a substantial asphaltic wearing surface, as in the case of many city streets, park drives, suburban thoroughfares and in some instances country roads, it remains in place, giving better results than any other type of foundation.

The extended mileage of bituminous roads is proof of satisfactory service. When properly constructed they meet every traffic requirement. They possess the resiliency required for both horse and motor traffic. They are not transformed into mud or dust, are reasonable in first cost and in the case of exceptionably well built roads have sustained traffic for six to ten years without requiring repairs. When thoroughly good materials are used and these roads fail, it is almost invariably due to defective foundations.

Thus in the composite road the menace of failure due to structural faults in the distinct types known as bituminous and concrete roads is largely if not wholly removed. By combining them in the manner described asphalt and cement are permitted to perform the functions to which they are best adapted, the first providing a lasting and resilient wearing surface and the latter an indestructible and solid foundation.

No type of road has a fixed cost applicable to all localities, but the following figures are significant:

In an article on paving in small cities in Kansas, a leading engineering journal made the following statement:

> The paving in Newton last year cost $1.18 per sq. yd. for a 4-in. concrete base and a 2-in. wearing surface of asphaltic concrete. Pavements of this type in Newton have been down for 10 years without repairs of any kind.

These pavements stand the traffic of a town of about 8,000 population. The price given would mean, in the case of roads 16 ft. wide, a little over $11,000 a mile.

In 1914 Mr. Henry G. Shirley, Chief Engineer of the Maryland State Road Commission, rebuilt a section of Belair road, just out of Baltimore, putting down 4 in. of concrete with concrete curbs and 2 in. of asphalt macadam. This section is 16 ft. wide and approximately 5 miles long. It cost a little under $13,000 a mile—only $450 more per mile than the average cost of Maryland's waterbound macadam roads. A report received during the latter part of May stated that nothing had been spent for maintenance. The road has been called upon to sustain the heavy traffic of motor trucks as well as general traffic to and from Baltimore.

Northeast Boulevard, Philadelphia, is constructed in part with 4 to 5 in. of concrete carrying a 2-in. asphalt macadam wearing surface. These sections were laid at a cost of about $1.25 per sq. yd. Needless to say they carry many times the traffic of a country road.

Contracts were let recently for the construction of approximately 40 miles of 16-ft. roadway in Monroe county, Michigan, the specifications calling for a 5-in. concrete base with 6-in. concrete curbs and a 2-in. asphalt macadam wearing surface. The several sections were let at an average price of about $13,400 per mile, this figure including grading, ditching and culverts.

The costs quoted show that the composite road can be built for less than many states and communities are paying for miscellaneous types of hard surfaced roads.

Thus it would seem feasible and economical for the country to adopt the composite road as a standard type. Construction methods would be rapidly systematized. Foundations could be increased or diminished in thickness to meet varying traffic requirements without radical departure from a common standard. Surface repairs or renewals would be less difficult. Extended mileage of a single type in a single state would result in economies difficult to obtain in the construction of miscellaneous types of roads. Construction methods would be simple and good results more certain. Matters would be simplified for the engineer and contractor. Furthermore, instead of having concrete roads in competition with bituminous roads, and vice versa, there would be co-operative effort looking to the substitution of the standard road for uneconomical macadam roads. The low initial cost of the composite roads already built invites effort in that direction.

Very truly yours,
E. A. Trego.

Philadelphia, Pa.

## COST OF CUTTING EDGE OF CONCRETE WALK.

Contributed by H. R. Ferris, Victoria, B. C.

During the work on some street widening improvements, it was found necessary, in order to make room for a granite curb, to trim about 3 in. off the outside edge of a 4-in. concrete walk, and for a distance of 512 ft.

Although "trimming" of this sort frequently occurs on street widening jobs, the writer has never known costs of this sort to be kept, and the following information may be of use, notwithstanding the small size of the item.

The work was done by an unusually good workman, using a medium hand hammer and ordinary cold chisels.

The cost follows:

| | |
|---|---|
| Foreman marking and lining edge of walk, 2 hr. | $ 1.25 |
| Laborer cutting edge of walk, 24 hr. | 7.20 |
| Removing old concrete— | |
| Labor, 4 hr. | 1.20 |
| Teams, 1 hr. | .65 |
| | $10.30 |
| Cost per lineal foot | 2 ct. |

## EARTH ROAD CONSTRUCTION IN BOX ELDER COUNTY, UTAH.

Tractor-grader outfits are being used extensively in Utah on highway work. One of the most notable undertakings with these outfits was the construction of approximately 100 miles of earth road in Box Elder County, at an average cost of $275 per mile, not including bridges and culverts. This work was carried out in 1914 by the State Road Commission, of which Mr. E. R. Morgan is Secretary and State Road Engineer. The highway was constructed over a virgin soil, sage brush country, on a new location encircling the north end of Great Salt Lake. It extends southwestwardly from Snowville to intersect the Nevada line just west of Lucin and forms part of the Midland Trail.

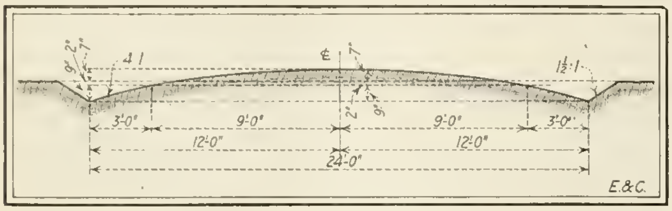


Fig. 1—Cross Section of Midland Trail, Box Elder County, Utah.

A good sized nucleus for the construction of this road was formed in 1913, when the State Legislature appropriated $15,000 for the construction of this particular link of the Midland Trail in Utah. An additional amount of approximately $12,500, required for the construction of the road, was supplied from the State Road fund of Box Elder County.

A broad reconnoissance of this road was made originally by automobile, followed by a rough preliminary survey which was made with a compass and hand level, aided by the existing government survey. The final location shortly preceded the construction of the road, so that the locating engineer was able to inspect the construction at reasonable intervals. The location was chosen preferably along township and section lines in surveyed regions, but allowed to meander along foothills through unreclaimed lands.

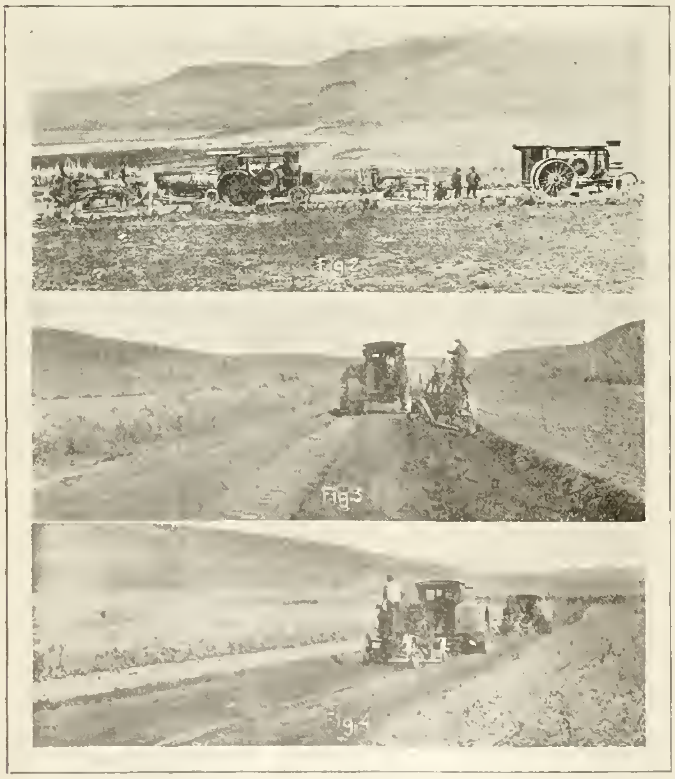


Fig. 2—Tractor-Grader Outfit. Fig. 3—Making First Ditch Cut. Fig. 4—Road Bed Grading.

The construction of the road was the most novel feature of the undertaking. Two International Harvester Co.'s Mogul, gasoline, 60-HP. traction engines and two road graders handled the work almost exclusively. A cross section 24 ft. wide from gutter to gutter with 9-in. crown above the shoulders was adhered to almost entirely, the width of the road being increased, however, to 30 ft. in width, through towns and settlements. The cross section mentioned is shown in detail in Fig. 1.

The progress of the grader and traction work on the longer tangents of the road amounted to an average of 1¼ miles per ten-hour day, the cost being $75 per day, or a unit cost of $60 per mile. The record run made on this project for grader and tractor work was 2½ miles per day at the same rate, amounting to only $30 per mile of road, thereby surpassing all previous records for speed and economy of road construction in the State. Surveying, clearing right of way, plowing and finishing, however, amounted to considerable; moreover, many stretches required team and hand construction. The average cost of the 100 miles of road was $275 per mile, not including bridges and culverts.

Since this road was constructed it has been maintained in the following manner: Each spring a complete grading of the road is made with a horse-drawn grader. The grader travels the full length of the road and back again. This work is done immediately after the breaking of winter, when the ground is damp, at which time the work of the grader is most efficient. In addition to this operation the road is dragged after each rain when the road surface is moist. A very smooth and lasting surface is obtained from dragging comparatively wet ground, as the kneading process seems to impart a certain toughness or increased cohesion power to the material, such that it will dry out into a compact cemented form which will not crack from the heat of the sun.

## STREET PAVING IN 1915 IN MANHATTAN BOROUGH, NEW YORK CITY.

The Bureau of Highways of the Borough of Manhattan, New York City, has under its jurisdiction about 479 miles of streets. Of this amount 115.33 miles are stone block, 248.92 miles sheet asphalt, 55.58 miles block asphalt, 34.5 miles wood block, 4.5 miles macadam and 20 miles of earth road. Some interesting data on the activities of the Bureau in 1915 are given in the annual report of Eugene W. Stern, Chief Engineer. The following extracts are taken from Mr. Stern's report.

During the year there was laid 10.6 miles of new pavements, costing $646,790, as follows:

| | Quantities | | Cost | |
|---|---|---|---|---|
| | Sq. yd. | Miles. | Per sq. yd. | Total. |
| Granite block | 66,473 | 2.71 | $3.74 | $346,041 |
| Sheet asphalt | 142,347 | 7.45 | 1.68 | 267,734 |
| Block asphalt | 915 | 0.05 | 2.47 | 2,760 |
| Wood block | 6,025 | 0.30 | 3.12 | 30,255 |
| Total | 215,760 | 10.60 | ...... | $646,790 |

During the year 1915 there was an average of 335.25 miles of street pavements, which were out of guarantee and were maintained by the Bureau of Highways at a cost of $440,666 as follows:

| | Quantities | | Cost | |
|---|---|---|---|---|
| | Sq. yd. | Miles. | Per sq. yd. | Total. |
| Granite and other kinds of stone pavement | 2,545,511 | 115.33 | $0.081 | $206,968 |
| Sheet asphalt | 3,097,584 | 165.03 | 0.069 | 225,637 |
| Block asphalt | 1,061,124 | 45.14 | | |
| Wood block | 87,734 | 5.24 | 0.044 | 3,926 |
| Macadam | 83,917 | 4.51 | 0.053 | 4,135 |
| Total | 6,875,870 | 335.25 | ...... | $440,666 |

The experience gained in this and the other boroughs of the city, also from a thorough study of the problem in all its phases both in this Bureau, has simplified the selection of the best pavements for this borough. Granite gives the best results for heavy traffic business streets; sheet asphalt for light traffic streets and those thoroughfares on which the traffic, although comparatively heavy, is confined largely to moderate weight vehicles on rubber-tired wheels, and wood blocks for streets with heavy traffic where it is essential to have quiet on account of schools, court houses, high office buildings, etc.

The wearing surface of a pavement is dependent for its life, continuity of surface and freedom from defect upon the character of the base upon which it rests. In recent years all pavements have been laid on a 6-in. concrete base and the question is often raised as to the desirability of increasing this depth on account of heavy traffic and to provide sufficient strength in the base to span settlements, caveins and shrinkage in the subgrade. Investigation of the failures in concrete foundations in this city shows that unless there is reason to believe that the subgrade is a recent fill, 6 ins. is adequate and is able to support the pavement under normal loads.

The policy of providing all main thoroughfares and the better class of residence streets with granite curbing and less important streets with bluestone has been continued. All corner curbs and headers are of granite.

The changing of curb corners from 6-ft. radii to 12-ft. radii has proven to be of such great advantage that the practice has been continued and is required wherever the curb is disturbed by repaving, building operations or sidewalk renewals.

The introduction of basins and inlets away from the corner at the building line has been continued with resultant improvement in drainage, dry crosswalks, shallower gutters and the abolition of the old corner receiving basin with its gaping jaws and offensive odors.

The concrete foundations under all types of pavement laid in 1915 were 6 in. thick, laid in the proportion of 1 of Portland cement, 3 of sand and 6 of broken stone.

Great care has been given to the preparation of the subgrade, and very close attention has been given to the composition and mixing of concrete for the base. Aggregates are required to be well graded from fine to coarse and the mixing must be thoroughly done in a revolving batch mixer, 20 revolutions of the mixer as a minimum being specified and insisted upon. The result has been a very high grade concrete base, fully up to the best standards of present day practice.

The Bureau, continuing its fixed policy of getting the best pavements possible, has made further progress towards obtaining the ideal granite pavement by making certain improvements in the details of construction during 1915.

As a result of careful investigation of the physical condition of our most recently constructed granite pavements, it was decided to make some important changes in the specifications in order to effect still further improvements.

Until recently sand has been used exclusively as a bed under granite pavements. Experience has proven that where openings had been made, there were places where water would percolate, causing a sinking of the blocks into the sand bed. This also happened where the crown of the pavement being flat, and slightly uneven, was prevented from drainage off promptly.

To obviate the formation of these depressions a mortar bed, consisting of 1 part Portland cement to 3 parts sand has been substituted for the sand bed, so-called cushion. This has proven entirely satisfactory, and the resulting improvement in the pavement has fully justified the change.

For some time it has become apparent that the paving pitch for filling the joints, made of coal tar, was not giving satisfaction. At the end of even one year the joints would not remain filled. This was due to the fact that in warm weather the coal tar filler would soften and leave the joints, and in cold weather it would chip out. When the joint does not remain filled, the paving blocks will quickly wear round on the edges and soon a noisy rough pavement will be the result.

To improve this condition, early in the year 1915 asphaltic joint filler was adopted, for the reason that it had greater tenacity, was less brittle in cold weather and not so soft in warm weather; hence promised better.

The granite block pavement is laid on a 6-in. concrete foundation, over which is spread a 1-in. mortar bed. The blocks measure from 6 to 10 in. in length, $3\frac{1}{2}$ to $4\frac{1}{2}$ in. in width and from $4\frac{3}{4}$ to $5\frac{1}{4}$ in. in depth. They must show no irregularities on the head of the block more than $\frac{1}{4}$ in. measured from a straight edge. The blocks are laid stone to stone, and the joints must not exceed $\frac{3}{8}$ in. in width. They are then rammed to a firm bearing. The use of pinch-bars is not permitted in the backramming. A mixture of fine sand and paving pitch is poured into the joints until full.

Considerable thought and investigation have been devoted to the specifications for wood block, with the result that it is believed that a pavement will result that will be free from the objectionable features of bleeding or oozing of the oil, and from bulging.

To avoid the bleeding, the blocks, besides the ordinary treatment when being creosoted, have a final steaming and vacuum treatment, and the amount of oil has been reduced from 18 to 16 lb.

To avoid bulging of the pavement, expansion joints have been provided along the curb, also a bituminous filler is used in the joints between the block.

The blocks under the revised specification are 4 in. wide by $4\frac{1}{4}$ in. deep and vary in length from 8 in. to 12 in.

The foundation is 6 in. concrete, over which is spread a $\frac{1}{2}$-in. mortar bed.

No substantial changes have been made in the asphalt specification. The penetration has been lowered, varying from 30 to 40, depending on the traffic conditions, etc. It is believed that this will prevent the waves and rolls which the softer asphalt developed under intense automobile traffic.

The sheet asphalt pavement consists of $1\frac{1}{2}$-in. close binder course laid on a 6-in. concrete foundation. Over the binder is placed a $1\frac{1}{2}$-in. top coat or wearing surface. It is then thoroughly rolled until satisfactory compression is obtained.

## METHOD OF CONSTRUCTING SAND-CLAY ROADS IN GOLDSBORO TOWNSHIP, N. C.

The following description of the methods employed in the construction of a system of sand-clay roads in Goldsboro Township, N. C., is taken from the recently issued proceedings of the Second Good Roads Institute of North Carolina:

The road was graded true to grade and the deep sandy places left flat; the clayey places shaped true to crown. On the sandy foundation there was placed 3 in. of good rich clay, spread over a width of 20 ft. This was then plowed, beginning at the sides and turning out until the entire road was plowed. Next there was placed on the road a double roll disk harrow of ten disks to the roll and the road was harrowed until the material was thoroughly pulverized, when it was again harrowed, beginning at the middle of the road and turning the material in until the entire road was plowed, care being taken in each instance not to take too much width at each furrow. The road was then harrowed with the same disk harrow as before until the material was thoroughly pulverized. The next step was to shape up the road with a road machine and allow it to rest until the first good soaking rain, when it was thoroughly puddled with a tooth harrow until it was a complete slop, then allowed to dry out; and while drying the road drag was used to keep it in shape until it was thoroughly dry, and true to shape. Over this there was then hauled and spread 3 in. of the best sharp, coarse, gravelly sand, and allowed to lie until the first rain, when this was cut in with a disk harrow and thoroughly puddled as before. The clayed places were plowed to a depth of 3 in., beginning on the edge and turning the furrow out, thoroughly disked, and over a width of 20 ft. was placed 4 to 6 in. of good sand, sharp and coarse, thoroughly disked in and again plowed, beginning at the middle and turning the furrow in toward the middle of the road, again thoroughly disked until all the material was completely pulverized, shaped true to section and allowed to rest until the first soaking rain, when it was thoroughly puddled and then handled as clay on sand, as described above.

Goldsboro is the center of trade for Wayne County and much of the surrounding territory. As these roads begin at the edge of Goldsboro and lead to the township line, supplying a well developed agricultural section beyond, the traffic, both on rubber and steel tires is very heavy. During the heavy rains these roads have held up almost perfectly in spite of the heavy traffic coming upon them, much being on heavily loaded wagons with narrow tires.

## COST OF PLACING 53 CONCRETE FOUNDATIONS FOR ELECTRIC LIGHT STANDARDS.

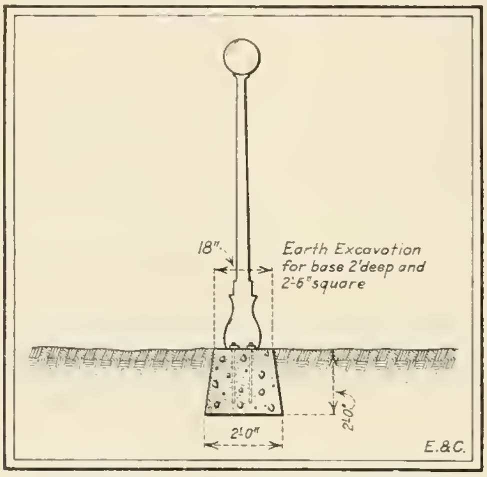
Contributed by H. R. Ferris, Victoria, B. C.

The following information covers the labor cost of placing 53 concrete foundations of the dimensions shown on the accompanying sketch for cast iron street light standards.

The costs, which follow, are considered high:

| | | Cost per base. |
|---|---|---|
| Foreman (marking location, etc.), 10 hr. @ 50 ct. | $ 5.00 | $0.09 |
| Labor excav. (pick and shovel dirt), 52 hr. @ 30 ct. | 15.60 | 0.29 |
| Labor placing forms and concreting, 46 hr. @ 40 ct. | 18.40 | 0.35 |
| Labor placing forms and concreting, 250 hr. @ 30 ct. | 75.00 | 1.41 |
| | $114.00 | |
| Cost of clean up and removal surplus earth | .25 ct. per base | |
| Distribution (and waste) of materials | .18 ct. per base | |

"Take down" forms were made in advance, which, including the anchor bolt templates cost $3.25 each. It was found quite impracticable to separate the cost of taking down and placing the forms, from the cost of the concrete work. Four fairly good workmen were employed on this work. The standards were 180 ft. apart and "staggared" on opposite sides of the street. Water for mixing was conveniently placed and the proper amount of materials were distributed in place.



Concrete Foundation for Electric Light Standard.

## MILEAGE AND TYPES OF ROAD SURFACES IN MIDDLE ATLANTIC STATES.

Interesting figures on road expenditures and road construction in the states of New Jersey, New York and Pennsylvania are given in a recently issued bulletin of the U. S. Department of Agriculture. According to this the total road expenditures in these three states in 1914 was $40,864,831, divided up as follows: New York, $23,231,964; New Jersey, $7,208,287; Pennsylvania, $10,424,580.

The total road mileage in the three states to Jan. 1, 1915, was 185,770.84, of which 31,516.23 miles, or 16.9 per cent of the total, were surfaced. This does not include streets in incorporated cities and towns, except a few miles in New York and Pennsylvania where the State roads pass through the small towns and boroughs. By comparing these figures with former investigations in the same States, it appears that between 1909 and 1914, 11,942.80 miles, or 6.4 per cent of the total, were surfaced. Table I summarizes all of the available information concerning road mileage for the three States.

TABLE I.—ROAD MILEAGE, 1909 AND 1914.

| State. | Total road mileage. | Miles surfaced. | Miles surfaced from 1909 to 1914. | Percentage surfaced. 1909. | Percentage surfaced. 1914. | Increase over 1909 Per cent. |
|---|---|---|---|---|---|---|
| New York | 79,398 | 15,635 | 2,848 | 16.13 | 19.6 | 3.5 |
| New Jersey | 14,817 | 5,897 | 2,475 | 22.76 | 39.8 | 17.0 |
| Pennsylvania | 91,556 | 9,982 | 6,618 | 5.84 | 10.9 | 7.0 |
| Total | 185,770 | 31,516 | 11,492 | 14.91 | 16.9 | 6.4 |

A diagram (Fig. 1) shows the percentage of surfaced roads for these States at the close of the years 1904, 1909, and 1914. This diagram shows in a striking manner the strides which have been made during the past 10 years in road construction in these States.

The bulletin also gives some interesting statistics on the changes in the types of road surfacings during the 10-year period, 1904-1910. Of the 10,485 miles of surfaced roads in the Middle Atlantic States in 1904, approximately 60 per cent was plain macadam and 40 per cent was gravel. In 1909, of the 19,532 miles of surfaced road, 51 per cent was macadam, 47 per cent gravel, 1 per cent bituminous macadam, and 1 per cent other materials. In 1914, however, of a surfaced mileage of 24,482, 39.3 per cent was macadam, 36.3 per cent gravel, 15.4 per cent bituminous macadam, 3.8 per cent brick and concrete, and 5.2 per cent of other materials. It should be stated, however, in this connection that the 24,482 miles do not represent the total mileage of surfaced roads in 1914, as in the case of Pennsylvania it was impossible to secure detailed information regarding the type of surfaced roads in second-class townships. The decrease in the percentage of macadam roads from 51 per cent in 1909 to 39.3 per cent in 1914 was due to the fact that many of these roads have been surface-treated and are now classed as bituminous macadam or bituminous-treated roads.

Of the 11,942.8 miles surfaced from the close of 1909 to the close of 1914, 9,629.82, which excludes second-class township roads in Pennsylvania, are classified as follows: 3,539.15, or 37 per cent, were treated with bitumen in some form; 1,992.75, or 20.5 per cent, were plain macadam; 2,501.32, or 26 per cent, were plain gravel; 485.95, or 5 per cent, were brick or concrete; and 1,110.65, or 11.5 per cent, were of other materials. This, states the bulletin, indicates conclusively that in the sections of country where heavy automobile traffic prevails, the old standard type of waterbound macadam has had its day.

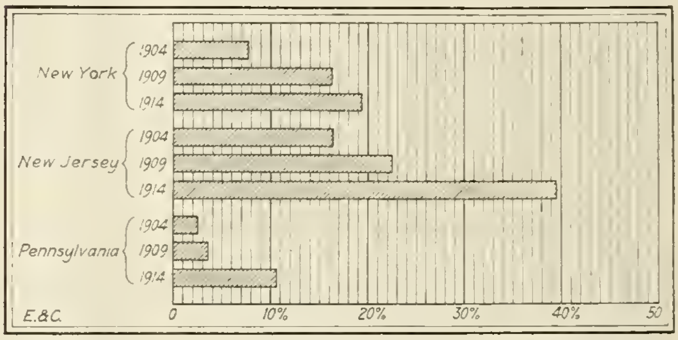


Fig. 1—Percentage of Surfaced Road in New York, New Jersey and Pennsylvania.

Detailed information on the mileage of improved surfaces, by years and States, is shown in Table II.

TABLE II.—PERCENTAGE BY TYPES OF SURFACED-ROAD MILEAGE.

| State. | Year. | Macadam. | Gravel. | Bituminous. | Brick. | Concrete. | Other materials. |
|---|---|---|---|---|---|---|---|
| New York | 1904 | 37.2 | 62.8 | .... | .. | ... | ... |
| | 1909 | 36.1 | 63.9 | .... | ... | ... | ... |
| | 1914 | 38.0 | 37.1 | 20.0 | 1.0 | 1.6 | 2.2 |
| New Jersey | 1904 | 73.4 | 17.2 | .... | ... | ... | ... |
| | 1909 | 76.8 | 17.0 | 6.2 | ... | ... | ... |
| | 1914 | 30.7 | 48.5 | 7.0 | ... | 4.3 | 9.5 |
| Pennsylvania | 1904 | 100.0 | .... | .... | ... | ... | ... |
| | 1909 | 82.1 | 13.0 | .... | ... | ... | 4.9 |
| | 1914 | [1]63.9 | [1]7.9 | [1]6.7 | [1]9.1 | ... | [2]12.4 |

[1] State highways only. [2] Concrete, stone block, flint, and stone.

## OPPORTUNITIES IN KENTUCKY FOR ROAD AND BRIDGE CONTRACTORS.

The 1914 session of the State Legislature of Kentucky passed a law giving State Aid to the building of roads and the inter-county-seat system was adopted. It is estimated that the total work of the inter-county-seat system will be something around 6,000 miles and that the cost will be something like $30,000,000.

In 1915 contracts were let for approximately 800 miles of road, some 450 miles of which were completed during the year at a cost of $1,400,000.

During 1916 to date contracts have been let for about 500 miles at a cost of something like $2,000,000 including culverts and bridges. Due to the fact that the work is to be done under engineers' supervision, which has encouraged the voting of bonds for the building of roads, some 30 odd counties have voted bonds aggregating over $6,000,000. It is the hope of the Department of Public Roads that the work of 1917 will be let early in the spring in order that it may be completed during the season. Owing to the fact that so many of the counties who have voted bonds will let a great deal of work during next year, it is believed the road work in this State next year will amount to about $4,000,000.

All types are being built and prices for the work vary in different sections of the State depending on the availability of material, etc. As a rule labor is plentiful in Kentucky and it has been found that best results can be gotten with local labor.

All drainage structures up to 30-ft. span are built of reinforced concrete, beyond that steel truss bridges are usually built with either masonry or concrete substructure. Rodman Wiley, Frankfort, Ky., is State Commissioner of Public Roads.

## SAND SPREADER FOR STREET OILING.

The sand sprinkler shown in the accompanying illustration is being used with excellent success by the city of Victoria, B. C., in connection with its street oiling work. The hopper, made in the city's machine shop, was attached to the rear of the motor truck. This hopper feeds onto a circular plate rotated by bevel gears and a chain and sprocket drive from the rear axle of the machine. Two men are stationed in the truck to keep the hopper filled with sand. The wrought iron whirling plate is 30 in. in diameter and is divided into four sectors by angle iron plates, forming vertical, radial ridges, which, as the plate revolves, act in the same way as the vanes of a centrifugal pump and cast the sand outward upon the road surface in the form of an evenly distributed shower. The sprinkler will spread sand over a 10-ft. width of roadway. When the truck travels at the rate of 3 miles per hour the disk rotates at a speed of 285 r. p. m.

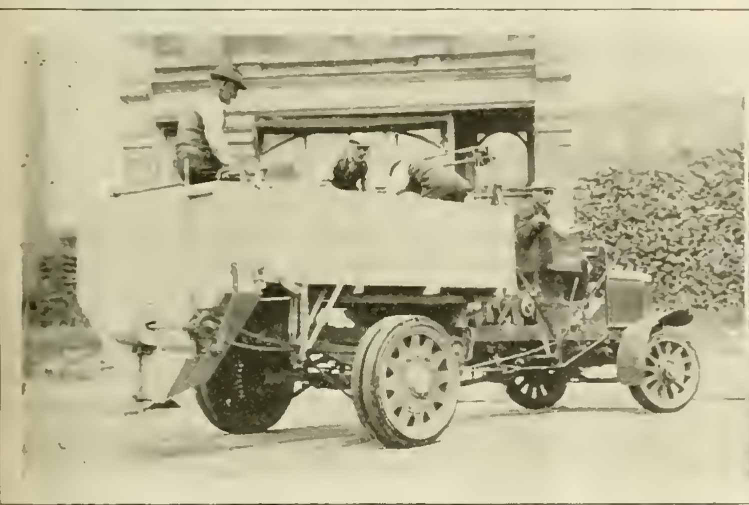


Fig. 1—Sand Sprinkler, Victoria, B. C.

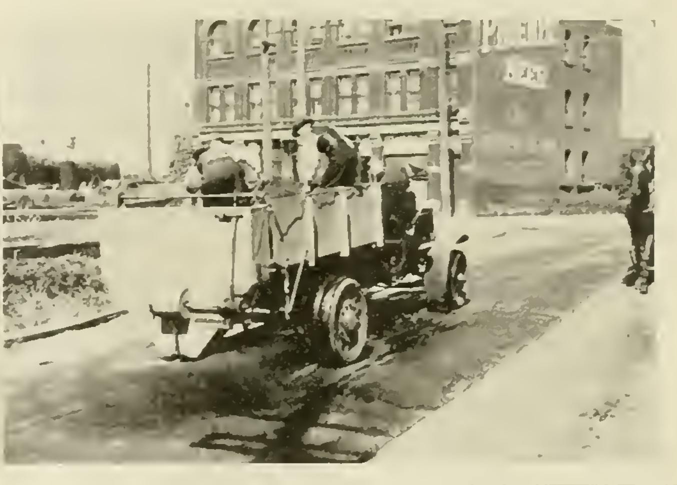


Fig. 2—Sand Sprinkler in Action.

## WIDTH AND FINAL DEVELOPMENT OF PAVED COUNTY HIGHWAYS SUITED TO WESTERN WASHINGTON.*

Where the number of vehicles passing in a given time is relatively small, roads may be built and pavements laid simply to suit the convenience of one vehicle, with turnouts or passing places, constructed at reasonable intervals, and in the matter of economy both of original construction and of maintenance to so build is in accordance with good sound sense. Roads so built should probably have a width of approximately 9 ft. and on such roads two elements must be carefully considered:

1st. The road must not have much crown; indeed, must be practically flat, and

2nd. The edges must be constructed particularly strong, so that vehicles passing off to one side or returning again, will not cause the margins of the pavement to be broken down.

When traffic has increased so that a road 9 ft. in width is sufficient to accommodate conveniently its users, the additional width necessary to be laid down is something which has been a matter of very great dispute and controversy, and total widths varying from 12 ft. to 20 ft. have been adopted. I have been impressed with the belief that a 16-ft. roadway is the minimum width to be considered and that an 18-ft. roadway is by far the preferable width. Many persons hold that with a good berme, the 16-ft. roadway is ample. There are several reasons why that width under present conditions, seems to me to be too narrow.

1st. It is difficult to construct a safe berme at the time of first constructing our country pavements. The ground is too soft to hold the load that passes upon it, and if perchance in time the ground becomes sufficiently firm and a fair stand of grass grows upon the berme, when any vehicle passes from the pavement upon the grass, if the grass is the least bit wet, the tendency is to cause the vehicle to skid and pass into the ditch.

2nd. Another reason is that on our motors we are now using almost exclusively the left drive, and passing to the right. The result is that the driver cannot see clearly and easily the relation of the right wheels to the margin of the pavement, and, therefore, hesitates to drive sufficiently far from the center of the road to permit proper passing. On meeting heavy freight trucks, the truckman, unable to gage his relation to the margin, and fearing the ditch, tends to hold too far toward the center of the road and forces the passenger motor off.

3rd. The third reason is an element in the structure of the pavement, itself. Where the pavement is narrow and the heavy load is compelled to seek a line close to the outer margin of the pavement, there is great danger of breaking down the edge, and, in particular, if the heavy load passes from the pavement to the berme and returns again, the tendency is, and the almost certainty exists, that in returning, portions of the edge of the pavement will be broken; and it is notoriously more difficult to maintain and repair the margins of the pavement than the center.

Taken all in all, therefore, I am inclined to recommend the width of 18 ft. as the minimum width of road surface, where the traffic is such as to render a road of a greater width than 9 ft. a reasonable necessity, and in such case, the outer margins should receive special treatment to secure requisite strength.

The tendency in modern engineering appears to be to build a road with the least possible crown so that the travel may be borne with equal ease on all parts of the road. This custom follows the use of our smooth and impervious pavements. The maximum crown advocated at present, is about 1 in 50, or practically 2 in. in 8 ft. With a smooth surface roadway, even this crown sometimes appears to be higher than need be. After testing out the convenience of driving on transverse slopes of different rates, I am inclined to the belief that on a roadway 18 ft. in width, that a transverse slope of 1 in. in 9 ft. is sufficient.

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*Abstract of a paper presented at the recent general convention of the Washington County Commissioners and County Engineers by R. H. Thompson, Consulting Engineer, Seattle, Wash.

Every phase of the question of a crown, how much, how curved, and how to be proportioned, is fraught with difficulty and I have almost made up my mind to recommend that in roadways of 18 ft., instead of a circularly crowned roadway, the road be sloped in planes from the center to the side, having as I have said, a total drop of 1 in. in 9 ft.

In the State of Washington the public mind seems at the present time to have adopted as pavements for country roads about the following classes:

1st. Some form of asphaltic composition laid on a crushed rock or macadam base. So far as I can learn, a length of about 18 miles of this class of pavement is being built on the country roads in the state this year.

2nd. Asphaltic top on cement concrete base. Of this top of asphaltic composition, so far as I can learn, about 31½ miles of country road pavements are being laid this year.

3rd. Vitrified brick, laid in various manners, in part on sand cushion, and in part monolithic. All told, of vitrified brick pavements, I understand there are being laid down on country roads this season, about 42½ miles.

4th. Cement Concrete Pavements: These pavements are of two types, single course and double course. I have no definite figures as to the particular amount of each type being laid down, but, so far as I can gather the statistics, there are about 151½ miles of cement concrete pavements, being constructed in the State of Washington on country roads this year.

The average costs of these various types of pavements, so far as I have been able to collect them, have been as follows:

| | Per mile. |
|---|---|
| Asphalt on crushed rock base | $16,300 |
| Asphalt on concrete base | 15,300 |
| Vitrified brick | 25,500 |
| Concrete | 12,300 |

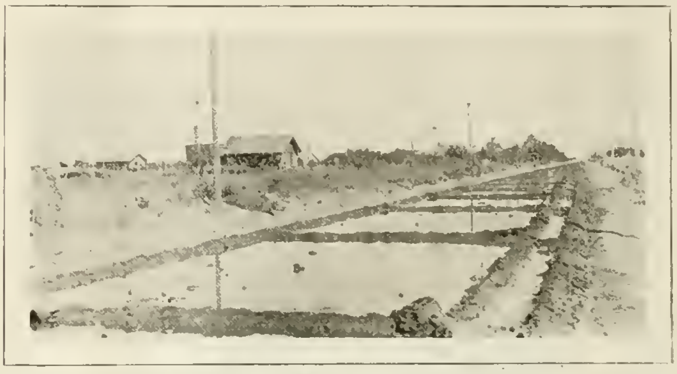
Almost every well located country paved roadway must, in a very short time, provide a foot path or sidewalk for the children going to and from school as well as for other pedestrians, such foot path to be separated from the main pavement by some form of guard or railing. The greater the thoroughfare, the more the necessity of caring for the pedestrian. We must also provide what might be termed a "bridle path" which means either an earthen roadway or a slightly gravelled roadway, on which horses, sheep and cattle, being moved from one place to another, can travel in comfort and safety.

The question comes, what width must be secured for rights of way? Taking into consideration, paved highway, bridle path, foot path, ditches, and perchance, some shade trees, nothing less than 50 ft., and, probably better, 60 ft., should be had. For instance, I would say: That in all cases where a country road may ever develop into a thoroughfare, that right of way should be secured for a final paved roadway of at least 26 ft., with not less than 1 ft. on each side as a shoulder between the pavement and the edge of the ditch, and a space of 3 ft. on each side for ditch. For foot path between the ditch and fence line, we should have 8 ft., because, as time goes on, we will have some shade trees, and for bridle path, across the road from the foot path and outside of the ditch, we should have at least 12 ft., and to make a definite separation of the bridle path from the pavement, it is advisable to plant a row of trees near the ditch. Separated thus by a row of trees, this makes the bridle path more like a lane, and when the cattle or horses or sheep have once found their course on the softer ground and in what appears to be a lane, the tendency is to maintain that course and leave the paved roadway free. These widths which I have specified, aggregate 54 ft. It is not always necessary or convenient or expedient that either the foot path or bridle path be maintained at the same level as the surface of the pavement. Where examination shows that it is expedient to construct these at a different level, a wider right of way may have to be obtained, so that in many instances, a proper right of way for country paved roadways will not have parallel sides, but will have sides of varying widths dependent upon necessity and convenience, and in many cases on first construction the pavement should not be placed in the center of the right of way.

## CALIFORNIA METHOD OF PONDING CONCRETE ROADS.

California was, we believe, the first state to practice the flooding of the finished concrete pavement with a view to keeping moisture present, to enable the concrete to acquire strength and hardness under proper conditions.

Even where water is obtainable for use in this manner it is, of course, desirable to prevent unnecessary loss. This is particularly true in hot climates, where evaporation is rapid and where scarcity of water more often prevails.


View Showing Longitudinal Dike.

The original method of diking roads in California has been improved upon by adding an additional longitudinal dike near the edge of the concrete, as shown in an accompanying view. This prevents unnecessary loss of water and gives double assurance that concrete will be covered at the crown of the pavement as well as at the sides. These two precautions are very essential and the added dike seems to make the desired ends more certain.

## DOUBLE COURSE BRICK PAVEMENT.

An old brick pavement with an 8-in. gravel foundation on one of the heaviest traffic streets of Muscatine, Ia., was reconstructed at a cost of 40 cts. per sq. yd. The following account of the methods used is taken from the recently issued Proceedings of the Iowa Engineering Society:

The brick were loosened and the best brick were placed at the side of the street. Then a space at one end of the street 10 ft. in width, running transversely across the street, was cleared of all bricks and bats and a sand bed made to form the crown of the pavement. Upon this sand bed the remaining bricks upon the street were laid flat, whether they were half, quarter or badly worn whole bricks. After this it was merely a matter of preparing the sand bed and using up the remaining old brick which were near at hand on the street, laying them flat until the other end of the street was reached.

In the meantime another gang of workers were spreading a sand filler and bed ¾ in. in thickness on the bricks which had been laid flat. Upon this second sand bed the wearing surface of brick was laid, using all of the best brick taken from the street and supplying new brick where necessary. Elastic joint filler ⅜ in. in thickness was placed every 25 ft. transversely and along the curbs longitudinally and the surface of the pavement thoroughly rolled, after which the joints were flushed with cement grout. Most of the brick from the quarter to the curbs were as good as the day they were laid and it was only necessary to raise the crown of the pavement 2 in. at the center of the street and lower the base at the curbs. No material was hauled off the street except a few small pieces of brick.

## THE DESIGN OF FLAT ARCH CORRUGATED IRON CULVERTS FOR USE UNDER PAVED SEREETS.

Contributed by J. Alden Griffin, Consulting Engineer, Los Angeles, Cal.

It is comparatively recent that the manufacture of an iron of a very high degree of purity has been accomplished, thus accounting for the general lack of data on the longevity thereof when used in such structures as culverts and storm sewers. With the data available from the Bureau of Industrial Research, Washington, D. C., I prepared a specification which I believe will secure (within the limits of economy) an iron fully capable of resisting corrosion for a great many years, thus warranting its use under paved streets without the fear of having to replace it every few years. The following are the principal requirements of the specification together with my recommendations on the design and construction of flat arch culverts as made for the city of Los Angeles:

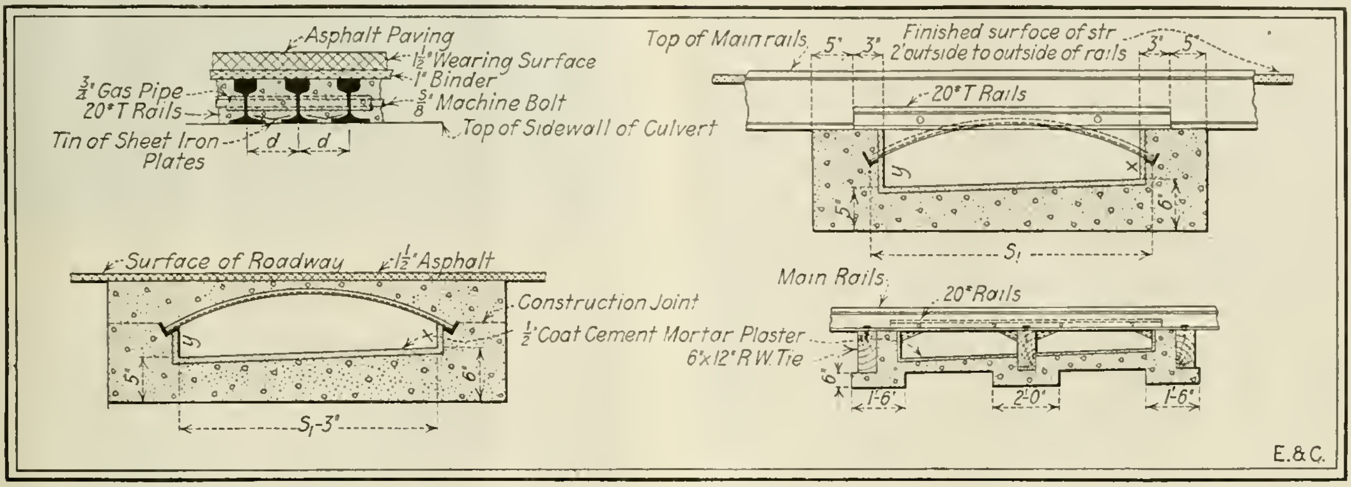


Fig. 1—Details of Flat Arch Corrugated Iron Culverts Under Streets.

The corrugated iron sheets used in the construction of culverts shall be thoroughly galvanized with not less than 2 oz. of zinc spelter to the square foot; the zinc spelter to be applied before the sheets are corrugated, and after being corrugated the sheets shall show no signs of cracking or blistering. The corrugations shall be standard, 2½ in. in width and ½ in. in depth. The sheets shall be of the gage shown on the plans and the iron of a high grade character, containing not less than 99.8 per cent pure iron, taking into account the following impurities in the order of their importance: Copper, carbon, manganese, sulphur, oxygen, phosphorous, silicon, nitrogen and hydrogen, the total content of which shall not exceed .2 per cent, and the maximum allowable percentage for any one impurity to be limited to the following:

| | Per cent. |
|---|---|
| Copper, not more than | .060 |
| Carbon, not more than | .040 |
| Manganese, not more than | .040 |
| Sulphur, not more than | .040 |
| Oxygen, nitrogen, hydrogen, not more than (estimated) | .035 |
| Phosphorus, not more than | .040 |
| Silicon, not more than | .015 |

Provided the sum total of all the impurities shall not exceed .2 per cent as above specified.

All joints in the arch metal shall be lapped not less than one corrugation and shall be riveted with rivets of the same quality as the iron arch where so indicated on the plans.

The ends of flat culverts under sidewalks are to be faced with a 1¼x1¼x⅛ in. angle iron, bent to the curve of the arch, riveted thereto and embedded flush with the face of the curb.

In deciding on the proper design for culverts of this type to be used under paved streets, several important points came up which required considerable study, especially in regard to the heavy loads now carried by the larger trucks and the maintenance of light or shallow curb faces, which meant that either the crown of the arch would have to be very near the surface of the roadway or the arch very flat in order to get much waterway area in the culvert: What should be the minimum rise to the span? What thickness of metal should be used? Should the metal be covered with concrete and if so, what should be the minimum allowable thickness in order that the elasticity of the metal would not be so great as to crack the asphalt and allow disintegration to set in through the action of water thereon? What cross-section for culvert would be best adapted to meet the above, minimize labor and friction resistance to flow and yet be of sufficient strength?

After considerable deliberation on the above I decided to test a flat arch under the heaviest loads carried by trucks in Los Angeles, which I did by having constructed a culvert to meet the dimensions I required, i. e., a 47-in. span with a 5-in. rise. Through a misunderstanding the supporting angles for the test culvert were placed at right angles to the springing line of the arch instead of perpendicular to the ends of the arch, which of course was a great detriment to the test piece as only a very small portion of the arch iron had contact with the angle which permitted the elongation of the arch and accompanying deflection under the load. The metal used was American Ingot Iron, No. 10 gauge. The load was 1,096-lb. per inch width of tire, or equivalent to more than 30-ton road roller. The arch was covered with 1 in. of concrete, which, due to the haste in which the test was made, was not thoroughly set and crumbled up when the load came on it with no asphalt covering to help distribute it. The arch as described deflected under the wheel approx. 5/16 in. to ⅜ in. and regained its original position with the exception of 1/16 in.

The conclusions I drew from the test and upon which I based my design for a standard plan are as follows:

(1) That the minimum rise to the span should be as 6 in. in 45 in. For table of "rise and radius" for different spans see Table No. I.

(2) That the minimum thickness of metal under the roadway should be No. 10 gauge iron. The thickness under the walk being best made of No. 14.

(3) That the corrugated iron should be covered with not less than 1½ in. of wearing surface and 1½ in. of concrete, or asphalt binder.

(4) That the angle iron skewbacks should be placed to bear as squarely as possible against the ends of the arch iron as indicated in Fig. 1, exercising great care to get the spans and the pitch of the angles exactly the same throughout any section of the culvert in order to prevent any giving or springing of the iron under the load. Figure 2 gives details for cutting screeds for placing the angles for different spans.

(5) That in placing railway tracks over a culvert the sidewalls should be built up of concrete or wood to support the track and sufficient of the arch cut away to permit the rails to pass through instead of allowing the rails to rest on or come in contact with the arch iron as the vibration from the cars would be detrimental to the paving.

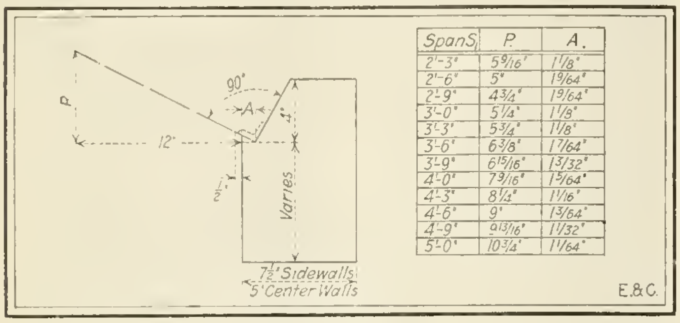
(6) That the bottom of the rails may be placed about 1 in. below the top of the arch without interfering with the flow, as the capacity will be maximum when the surface of the water is about 1½ in. down from the corruga-

TABLE I.—VALUES OF S, $S_1$ AND RISE AND RADIUS FOR COMMON SIZES.

| Clear span S.<br>Ft. In. | Arch span $S_1$.<br>Ft. In. | Arch rise R.<br>In. | Radius of arch.<br>In. |
|---|---|---|---|
| 2 0 | 2 3 | 3 | 32 |
| 2 3 | 2 6 | 3 | 39 |
| 2 6 | 2 9 | 3⅛ | 45 |
| 2 9 | 3 0 | 3¾ | 45 |
| 3 0 | 3 3 | 4 7/16 | 45 |
| 3 3 | 3 6 | 5 3/16 | 45 |
| 3 6 | 3 9 | 6 1/32 | 45 |
| 3 9 | 4 0 | 6 15/16 | 45 |
| 4 0 | 4 3 | 7 29/32 | 45 |
| 4 3 | 4 6 | 9 | 45 |
| 4 6 | 4 9 | 10 3/16 | 45 |
| 4 9 | 5 0 | 11 7/16 | 45 |

tions at the crown, and as this space will not be required for the capacity we gain the extra head room, which in some cases means a great deal, especially if there is a very flat grade across the street and very deep rails are used by the railway company.

(7) That when the culvert is of two or more compartments the center or intermediate wall or walls underneath the railway company's portion or track may be made of redwood or other suitable timber, in order to allow the tracks to be spiked down instead of being only supported for such long spans, and as this substitution is a direct benefit to the railway company in more ways than one, the maintenance thereof is their care, as is the paving and that portion of the culvert between lines 2 ft. outside of the outside rails of their track.



| SpanS | P. | A. |
|---|---|---|
| 2'-3" | 5 9/16" | 1 1/8" |
| 2'-6" | 5" | 1 9/64" |
| 2'-9" | 4 3/4" | 1 9/64" |
| 3'-0" | 5 1/4" | 1 1/8" |
| 3'-3" | 5 3/4" | 1 1/8" |
| 3'-6" | 6 3/8" | 1 7/64" |
| 3'-9" | 6 15/16" | 1 3/32" |
| 4'-0" | 7 9/16" | 1 5/64" |
| 4'-3" | 8 1/4" | 1 1/16" |
| 4'-6" | 9" | 1 3/64" |
| 4'-9" | 9 13/16" | 1 1/32" |
| 5'-0" | 10 3/4" | 1 1/64" |

Fig. 2—Diagram for Cutting Screeds for Placing Angles.

(8) That the flow line of the culvert should be along one side instead of in the center, especially for culverts of two or more compartments, as the depressed centers will not join up with a straight gutter grade and as this can be very nicely done by sloping to one side and also somewhat lessen the work of construction, I have adopted it for all sizes of culverts. The minimum grade on which culverts should be placed should be .35 per cent.

TABLE II.—TABLE GIVING SPACING "D" OF RAILS.

| District. | Load per wheel, lb. | Clear span. Ft. In. | Spacing "d." In. | Length of rails. Ft. In. | Weight of metal per lin. ft. of culvert, lb. |
|---|---|---|---|---|---|
| Wholesale or industrial ...... | 12,000 | 2 0 | 3 | 2 6 | 71.0 |
| | | 2 6 | 3 | 3 0 | 84.3 |
| | | Double 2" | 3 | 4 11 | 139.7 |
| Residence ...... | 6,000 | 2 0 | 6 | 2 6 | 37.6 |
| | | 2 6 | 5 | 3 0 | 52.3 |
| | | 3 0 | 4 | 3 6 | 74.3 |
| | | 4 0 | 3 | 4 6 | 124.3 |
| Hilly ........... | 4,000 | 2 0 | 6 | 2 6 | 37.6 |
| | | 2 6 | 6 | 3 0 | 44.3 |
| | | 3 0 | 6 | 3 6 | 51.0 |
| | | 4 0 | 5 | 4 6 | 76.3 |

(9) That it will not be necessary to rivet the sheets at each joint but provide laps of 1½ corrugations and rivet all intersecting wings where the same miter in.

(10) That the upper or intake end of the culvert should be made about 6 in. greater in width than the main portion in order to aid the entrance of the water and to effect the working of the culvert to its capacity.

(11) That the angle iron supporting the arch iron need not be of the same purity as the light iron of the arch, but should be protected by at least two coats of a good preservative paint, for instance, a first coat of Red Lead Lute and a second or finish coat of Carbon Black No. 925 A, both of which are manufactured by the Lowe Bros. of Dayton, O., or the angle might well be protected by covering it with a liquid or mushy grout before placing the arch iron thereon, which would completely embed it and thus protect it from the action of the water; or the angle might be galvanized; any one of the above being ample to protect it against corrosion indefinitely, especially if the plaster coat and the cement grout are applied properly, as the water will be prevented from following down the iron on to the angles. In fact, it would take years of corrosion even if the angle were unprotected to cause any serious effects, owing to the fact that the only portion of the angle required for the arch is that part entirely covered by the iron of the arch. It is therefore my personal opinion that the possibility of corrosion at this point affecting the life of the culvert need not be considered, especially if any of the above mentioned precautions are taken.

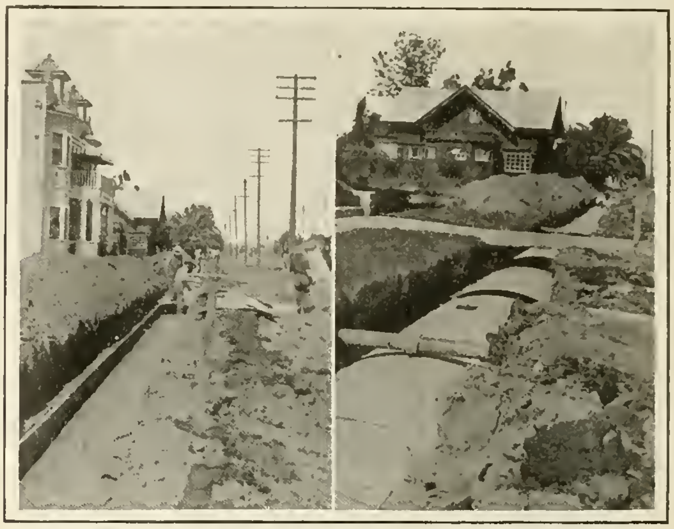


Fig. 3—Construction Views of Flat Arch Corrugated Iron Culverts.

TABLE III.—CAPACITIES OF ONE COMPARTMENT OF CULVERT ON VERY FLAT GRADES USING x=2" and y=3".

| Clear Span S. | Area of Opening A. | Area of Water a. | Wetted Perim. P. | $r = \frac{a}{p}$ | √r | C Bozin's Form. with c = .29. | ac√r | Q=Cubic ft. per sec. for Grades from 3/10% to 1% | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | .3% √s=.055048 | .4% √s=.063066 | .5% √s=.070173 | .6% √s=.07785 | .7% √s=.08371 | .8% √s=.08919 | .9% √s=.09485 | 1.0% √s=.1000 |
| 2.00 | .67 | .59 | 2.84 | .208 | .456 | 97.0 | 26.1 | 1.44 | 1.65 | 1.83 | 2.03 | 2.19 | 2.33 | 2.47 | 2.61 |
| 2.25 | .74 | .66 | 3.33 | .198 | .445 | 96.0 | 28.2 | 1.55 | 1.78 | 1.98 | 2.20 | 2.36 | 2.52 | 2.67 | 2.82 |
| 2.50 | .83 | .75 | 3.83 | .196 | .443 | 96.0 | 32.2 | 1.77 | 2.03 | 2.26 | 2.51 | 2.69 | 2.87 | 3.05 | 3.22 |
| 2.75 | 1.05 | .97 | 4.35 | .223 | .473 | 97.5 | 44.7 | 2.46 | 2.82 | 3.13 | 3.48 | 3.74 | 3.98 | 4.24 | 4.47 |
| 3.00 | 1.24 | 1.16 | 4.87 | .238 | .488 | 98.8 | 55.8 | 3.07 | 3.52 | 3.91 | 4.35 | 4.67 | 4.98 | 5.29 | 5.58 |
| 3.25 | 1.49 | 1.41 | 5.40 | .261 | .511 | 100.2 | 72.1 | 3.97 | 4.55 | 5.06 | 5.62 | 6.04 | 6.43 | 6.85 | 7.21 |
| 3.50 | 1.79 | 1.71 | 5.94 | .288 | .537 | 102.3 | 93.7 | 5.16 | 5.91 | 6.57 | 7.30 | 7.84 | 8.35 | 8.89 | 9.37 |
| 3.75 | 2.12 | 2.04 | 6.47 | .315 | .561 | 104.0 | 119.0 | 6.55 | 7.50 | 8.34 | 9.27 | 9.96 | 10.62 | 11.29 | 11.90 |
| 4.00 | 2.52 | 2.44 | 7.03 | .347 | .589 | 105.5 | 151.8 | 8.35 | 9.56 | 10.65 | 11.83 | 12.72 | 13.54 | 14.40 | 15.18 |
| 4.25 | 2.95 | 2.87 | 7.59 | .378 | .615 | 107. | 189.0 | 10.41 | 11.93 | 13.28 | 14.74 | 15.82 | 16.86 | 17.93 | 18.90 |
| 4.50 | 3.46 | 3.38 | 8.16 | .414 | .643 | 108.5 | 236.0 | 13.10 | 14.90 | 16.58 | 18.40 | 19.76 | 21.05 | 22.40 | 23.60 |
| 4.75 | 3.99 | 3.91 | 8.73 | .448 | .669 | 110. | 287.2 | 15.83 | 18.12 | 20.15 | 22.35 | 24.05 | 25.60 | 27.22 | 28.72 |

TABLE IV.—QUANTITIES OF CONCRETE, AND ARCH IRON PER LIN. FT. AND AREA OF OPENINGS FOR CULVERTS OF 1, 2, 3 OR 4 COMPARTMENTS.

| Clear Span S. | Rise in Ft. | One Compartment | | | | | Two Compartments | | | | | Three Compartments | | | | | Four Compartments | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Concrete. Cu. ft. | Opening. Sq. ft. | Extra for ea. 1" add. depth. Conc. | Open. | Arch Iron. Sq. ft. | Concrete. Cu. ft. | Opening. Sq. ft. | Extra for ea. 1" add. depth Conc. | Open. | Arch Iron. Sq. ft. | Concrete. Cu. ft. | Opening. Sq. ft. | Extra for ea. 1" add. depth Conc. | Open. | Arch Iron. Sq. ft. | Concrete. Cu. ft. | Opening. Sq. ft. | Extra for ea. 1" add. depth Conc. | Open. | Arch Iron. Sq. ft. |
| 2.00 | .25 | 2.80 | .67 | .11 | .16 | 2.33 | 4.74 | 1.34 | .15 | .32 | 4.66 | 6.68 | 2.01 | .17 | .48 | 6.99 | 8.62 | 2.68 | .23 | .64 | 9.32 |
| 2.25 | .25 | 2.99 | .74 | .11 | .18 | 2.57 | 5.12 | 1.48 | .15 | .36 | 5.14 | 7.26 | 2.22 | .17 | .54 | 7.71 | 9.38 | 2.96 | .23 | .72 | 10.28 |
| 2.50 | .26 | 3.19 | .83 | .11 | .20 | 2.82 | 5.51 | 1.66 | .15 | .40 | 5.64 | 7.83 | 2.49 | .17 | .60 | 8.46 | 10.15 | 3.32 | .23 | .80 | 11.28 |
| 2.75 | .31 | 3.44 | 1.05 | .11 | .22 | 3.09 | 5.97 | 2.10 | .15 | .44 | 6.18 | 8.51 | 3.15 | .17 | .66 | 9.27 | 11.03 | 4.20 | .23 | .88 | 12.36 |
| 3.00 | .37 | 3.78 | 1.24 | .11 | .24 | 3.36 | 6.60 | 2.48 | .15 | .48 | 6.72 | 9.43 | 3.72 | .17 | .72 | 10.08 | 12.24 | 4.96 | .23 | .96 | 13.44 |
| 3.25 | .43 | 4.09 | 1.49 | .11 | .26 | 3.64 | 7.17 | 2.98 | .15 | .52 | 7.28 | 10.27 | 4.47 | .17 | .78 | 10.92 | 13.33 | 5.96 | .23 | 1.04 | 14.56 |
| 3.50 | .50 | 4.48 | 1.79 | .11 | .28 | 3.93 | 7.88 | 3.58 | .15 | .56 | 7.86 | 11.29 | 5.37 | .17 | .84 | 11.79 | 14.68 | 7.16 | .23 | 1.12 | 15.72 |
| 3.75 | .58 | 4.88 | 2.12 | .11 | .30 | 4.21 | 8.61 | 4.24 | .15 | .60 | 8.42 | 12.35 | 6.36 | .17 | .90 | 12.63 | 16.07 | 8.48 | .23 | 1.20 | 16.84 |
| 4.00 | .66 | 5.25 | 2.52 | .11 | .32 | 4.52 | 9.29 | 5.04 | .15 | .64 | 9.04 | 13.34 | 7.56 | .17 | .96 | 13.56 | 17.37 | 10.08 | .23 | 1.28 | 18.08 |
| 4.25 | .75 | 5.69 | 2.95 | .11 | .34 | 4.83 | 10.09 | 5.90 | .15 | .68 | 9.66 | 14.50 | 8.85 | .17 | 1.02 | 14.49 | 18.89 | 11.80 | .23 | 1.36 | 19.32 |
| 4.50 | .85 | 6.15 | 3.46 | .11 | .36 | 5.15 | 10.93 | 6.92 | .15 | .72 | 10.30 | 15.71 | 10.38 | .17 | 1.08 | 15.45 | 20.49 | 13.84 | .23 | 1.44 | 20.60 |
| 4.75 | .95 | 6.65 | 3.99 | .11 | .38 | 5.47 | 11.85 | 7.98 | .15 | .76 | 10.94 | 17.06 | 11.98 | .17 | 1.14 | 16.41 | 22.25 | 15.96 | .23 | 1.52 | 21.88 |

(12) That this type of culvert is especially adapted to meet the hereinbefore mentioned requirements at approximately two-thirds of the cost of a reinforced concrete culvert of the same capacity.

Tables III and IV give approximately the capacity of culverts together with the number of cubic feet of concrete and the number of square feet of iron per linear foot of culvert.

The views Fig. 3 show fairly well a somewhat novel use of this form of construction. It has been extensively employed for culverts across street intersections, and frequently has been laid diagonally underneath sidewalks at the corners, thus serving to avoid several difficulties which are encountered in some installations; but, so far as I know, the plan of caring for drainage by laying part circle corrugated culverts with concrete bases, for long distances underneath the sidewalks is original in Los Angeles. There are a number of localities in this city where this method has proven very satisfactory. Number ten gage corrugated iron is employed at the street crossings and number sixteen or number fourteen under the sidewalks.

## CHART FOR DETERMINING QUANTITY OF ROAD OIL IN PARTLY FILLED TANKS.

Contributed by E. Earl Glass.

The graphic chart shown in the accompanying illustration was prepared by the writer for the quick determination of the quantity of liquid in a partly filled horizontal tank. It has proved very useful for measuring part tanks of road oil. The following example shows the method of use: $3\frac{1}{2}$ ft. of oil are measured in a $4\frac{3}{4}$-ft. diameter tank of 1,100 gal. capacity. Then $\frac{3.5}{4.75} = .74$ d = depth of oil. On the 0.74 horizontal line at 1,100 gal. curve, read 890 gal. contents.

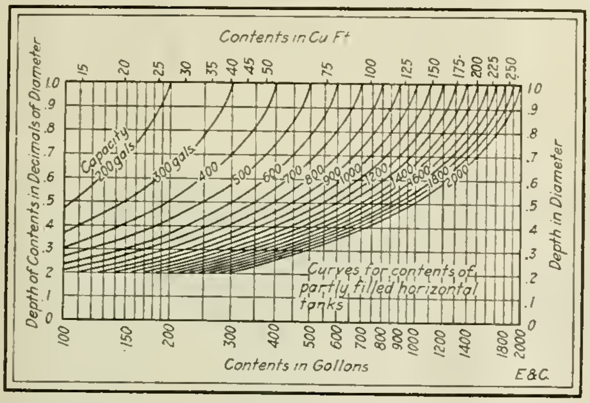


Chart for Determining Quantity of Road Oil in Partly Filed Tanks.

## REPAIRING PAVEMENT CUTS.

The Ottawa Gas Co. of Ottawa, Ont., is repairing its pavement cuts at an average cost of 20 cts. per sq. ft. The methods used are described as follows by Mr. P. S. Lamb, Superintendent of the Service Department, in a paper presented at the recent annual convention of the Canadian Gas Association:

When cutting pavement, we first take off the asphalt, lay it to one side, then take out the concrete, and lay it out of the way. When the work of repairing has been finished, the hole is filled up again, tamping everything back as before. We then mix the old concrete with about two bags of cement, adding a little sand.

After this has been put back, we mix what is left of the two bags of cement, with sand (mixing it up thoroughly), about 3 to 1, and place it on the top of the concrete which we have put back. Then we put on the asphalt, tamping it level, by using under the tamper a piece of plank long enough to catch the edge of the firm pavement. This piece of board keeps it to the exact level, and all cement that comes up around the edge of the cut is then leveled off, which completes the work. This is protected for 24 hours by a trestle, after which it takes a keen eye to detect the cut. The cost of this work would be as follows:

| | |
|---|---|
| 2 bags of cement at 60 ct. each | $1.20 |
| 2 men for one hour at 30 ct. per hour each | .60 |
| Total | $1.80 |

As the average cut is about 1 sq. yd. this would be exactly 20 ct. per sq. ft.

## ROAD CONSTRUCTION IN NATIONAL FORESTS.

Announcement has been made of the plan to be pursued in spending the $10,000,000 appropriated by the Federal Aid Road Act for the construction and maintenance of roads and trails within or partly within national forests. The sum of $1,000,000 has been tentatively allotted among the various national forest states for the present fiscal year.

The tentative allotments to the principal national forest states are as follows: Alaska, $46,280; Arizona, $59,795; Arkansas, $11,294; California, $140,763; Colorado, $62,335; Idaho, $108,010; Montana, $69,901; Nevada, $19,195; New Mexico, $42,622; Oregon, $127,794; South Dakota, $8,115; Utah, $40,982; Washington, $91,739; Wyoming, $40,566. In addition, a total of $9,552 has been tentatively assigned to Florida, Michigan, Minnesota, Nebraska, North Dakota and Oklahoma, while the eastern states—Maine, New Hampshire, Virginia, West Virginia, North Carolina, South Carolina, Tennessee and Georgia—in which the Government is purchasing lands for national forests, have been allotted $21,057.

In general the states and counties will be required to furnish co-operation in an amount at least equal to 50 per cent of the estimated cost of the surveys and construction. However, upon a satisfactory showing by the applicant state or county that such proportion of co-operation is inequitable, it may be altered and the ratio of co-operation fixed upon a basis equitable to both the state or county and the United States.

The method followed in apportioning the money was as follows: 10 per cent of the amount available each year will be withheld as a contingent fund. One-half of the remainder will be allotted to the states in amounts which will be based on the area of national forest lands in each state. The other half will be apportioned on a basis of estimated value of timber and forage resources which the forests contain. Amounts apportioned but unexpended within three years, and any balance of the contingent fund which remains unapportioned at the end of each year will be reapportioned on the same basis as the original allotments.

The two groups of states to which lump sums are allotted are to be considered as single units of apportionment. Apportionments now to be made are for the current fiscal year only. Thereafter new apportionments will be made, giving consideration to the number and character of applications made by the state and county officials for expenditures on specific projects. These applications must be filed with the district foresters in the seven national forest districts on or before Jan. 1 of each year for the fiscal year beginning the following July 1.

The determination of the projects upon which funds will be expended during the current fiscal year will be made on the basis of applications which must be filed with the district foresters on or before Oct. 1, 1916. Each application must contain a statement of the public needs to be served by the proposed road and the manner and extent to which it would aid in the development of resources upon which communities within or adjacent to the national forests are dependent, and must also show the general location of the proposed road and its estimated cost. As already stated, in general, states and counties must be prepared to furnish co-operation equal to at least 50 per cent of the estimated cost of surveys and construction. This co-operation may be in the form the form of money, labor and materials, or the construction of roads. Where other factors are equal, the approval of a project may be determined upon the relative amount of co-operation offered.

## NEW SPECIFICATIONS OF NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION FOR BRICK PAVEMENTS OF GREEN CONCRETE AND SAND-CEMENT SUPER-FOUNDATION TYPES.

The National Paving Brick Manufacturers' Association has just issued its new specifications for the construction of vitrified brick pavements of the green concrete foundation type and of the sand-cement super-foundation type. The specifications cover both street pavements and country roads constructed with these types of foundations. The requirements for the two types of foundation for highways are given below.

### Green Concrete Foundation Type.

Section 1. The subgrade, if dry, shall be lightly sprinkled with water before placing the concrete.

Finishing Green Concrete Foundation by Placing and Smoothing Concrete and Adding Thin Film of Sand and Cement.

Section 2. Concrete for the foundation shall be deposited, struck off and finished to the depth of........... inches as provided in the plans and specifications so that when complete, the surface shall be parallel to, and ......... inches below the grade of the finished roadway. The surface shall be smooth and uniformly finished, with the coarse aggregate thoroughly embedded in mortar. Concrete in place shall have been so mixed, deposited, and finished, that the coarse and fine aggregate shall be uniformly distributed throughout the mass (in the proportions provided in Item 4, Section 8).* The concrete shall be brought to the required surface smoothness, and condition for laying the brick thereon by adding thereto a thin coating of sand and cement.

Section 3. The sand and cement for the thin coating shall be of a quality equal to that used in the fine aggregate in the concrete. They shall be thoroughly mixed dry in advance in a mechanical batch mixer, in the proportion of 1 part cement to 3 parts of sand by volume. Mixing shall continue until the mass attains a uniform shade. Sufficient quantity shall be prepared at intervals in order that there shall be no interruption in preparing the surface of the concrete for brick laying.

Section 4. Steel forms shall be utilized to retain the concrete and brick and serve as guide rails for the template, and when so used shall be true to line and grade.†

Section 5. The concrete shall be brought within the requirements of Section 2 by means of a double template which shall consist of a 6-in. steel I beam in front and a 6-in. steel channel or I beam to the rear, held in a rigid frame with the two members parallel, spaced 2 ft. from center to center, and shaped to conform to the cross section of the roadway. The rear member shall be held in the frame with the bottom 3/16 in. higher than that of the frame member. Rollers shall be attached to the frame which shall rest, when in use, upon the guide rails.

In shaping the concrete deposited from the mixer, it shall be thoroughly spaded, settled and roughly surfaced immediately ahead of the double template. A sufficient amount of dry mixture for the thin coating shall be supplied continually between the framed templates so that in the forward movement, the rear template shall distribute the necessary film over the entire surface, producing the required smoothness.

Section 6. In cases where the use of the double framed template is impracticable, the required surface shall be secured by templates or by hand luting.

Note.—By reason of the fact that the rear cutting edge of the double template is 3/16 in. higher than the front cutting edge, the forward movement of the template as described performs two operations simultaneously, namely: That of striking off the concrete which has been deposited upon the subgrade and spreading over its surface the 3/16 in. film of the dry mixture, which being of equal quality of the mortar in the concrete becomes an integral part of the concrete.

Concrete of a consistency which will sustain the brick surface uniformly during the laying, rolling and filling the joints is a necessary prerequisite. It is equally necessary, too, that the green concrete shall be of a consistency affording a mortar surface which will insure a perfect adhesion of the brick.

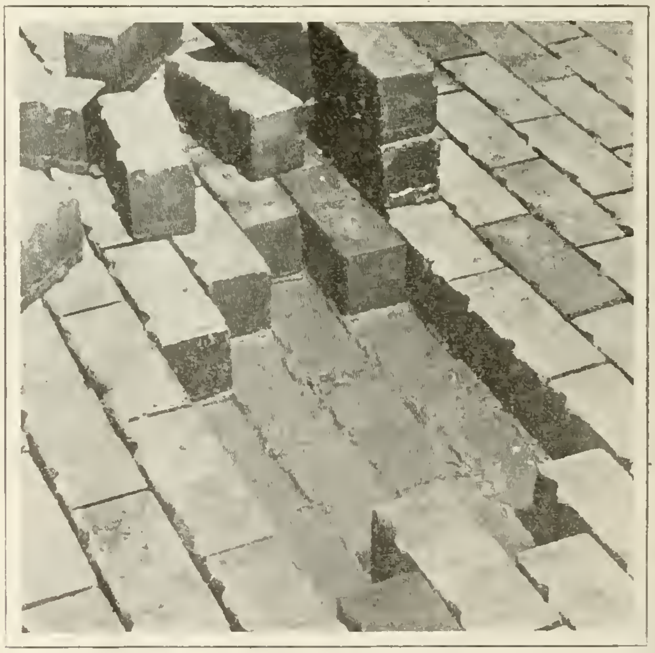
The use of transverse joints in the surface or base of the roadway should not be permitted.

Section 7. The use of partially hardened mortar or concrete, remixed with water, is prohibited.

Section 8. No concrete shall be mixed or deposited when the air temperature is below 32° F., unless during the mixing the aggregates shall be heated so that when placed, the temperature of the concrete shall be not less than 60° F. The pavement shall then be protected by sufficient covering against freezing. In no event shall concrete be deposited upon a frozen subgrade.

### Sand-Cement Super-Foundation Type.

Section 1. Upon that part of the foundation already prepared, there shall be added a superfoundation completing the whole, composed of 1 part of cement to 4 parts of sand, stone screenings or granulated slag, which when thoroughly rolled and compacted to uniform density by means of a hand roller, shall be not more than 1 in. in depth.



Appearance of Green Concrete Foundation After the Brick Surface Has Been Rolled.

Section 2. Cement used in the specifications shall be as herein provided in Item 4, Section 1.*

Section 3. Sand used in the superfoundation shall be as herein provided in Item 4, Section 2.†

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*Item 4, Section 8. The cement, coarse and fine aggregate, or if gravel be used, the combined aggregates, shall be measured separately and mixed in such proportions that the resulting concrete shall contain fine aggregate amounting to 50 per cent of the volume of the coarse aggregate, and that 7 cu. ft. of concrete in place shall contain 1 sack of cement or 94 lb.

†This requirement in the specifications for vitrified brick street pavements is as follows: "Section 4. Curbs, street railway tracks, steel or other forms shall be utilized to retain the concrete and serve as guide rails for the template, and when so used shall be true to line and grade."

*Item 4, Section 1. Cement used shall meet the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials adopted August 16, 1909, with amendments and additions thereto adopted by the said society.

†Item 4, Section 2. Fine aggregate shall consist of clean sand or of screenings from hard, durable rock or gravel, uniformly graded in grain size, 100 per cent of which shall pass a ¼-in. sieve mesh. It shall be free from soft, friable material, shale or slate, and vegetable or other organic matter, and shall not contain clay in excess of 5 per cent.

Section 4. The sand and cement for the added portion of the foundation shall be mixed in the proportions herein provided, by hand or mechanical mixer, until the mass attains a uniform shade and in such quantities that the operations of constructing the superfoundation may proceed continuously.

Section 5. The superfoundation shall be shaped to a true surface parallel with the surface of the finished brick road, by means of a template extending the entire width of the brick road, drawn forward upon the curbs or guide rails. When the width of the brick road precludes the use of a template spanning the entire distance the operations of shaping the superfoundation shall be performed upon sections thereof, using scantling laid upon the foundation as the guide rails.

Section 6. After the superfoundation has been spread and struck off to a depth not less than ¼ in. above the finished depth herein provided, it shall be thoroughly and uniformly compacted by rolling. The roller used for this purpose shall be of the hand type, weighing not more than 10 lb. per inch of length. It shall be not more than 24 in. in diameter, nor more than 30 in. in length.

Rolling shall commence at the curb and continue parallel to it at a slow pace, moving backward and forward until the opposite curb is reached. Any depressions created by rolling shall be lightly roughened by means of rakes and a sufficient quantity of aggregate mixture be added, so that when again struck off and rolled the surface shall conform to that herein provided.

The operations of striking off and rolling shall be repeated until the entire superfoundation is uniformly dense and free from depressions.

Section 7. When the use of the template and guide rails for striking off any portion of the superfoundation is impracticable, it shall be shaped to the surface required by hand luting. All provisions for rolling, compacting and smoothing shall be observed.

## STREET FLUSHING AT CHICAGO WITH AUTOMOBILE FLUSHERS.

The city of Chicago purchased three outomobile flushers in the fall of 1914. These were put in operation about April 10, 1915, and remained in the service until Nov. 19th, when weather conditions interfered with street flushing. During this period they were operated in two shifts of 8 hours each, making a total of 16 hours per day. For various reasons it was found most practical to have the drivers on the first shift report for work at noon to give their machines one hour's attention. Flushing operations would then begin and continue until 9:30 p. m. The night shifts reported for work at 9:30 p. m. and after caring for machines commenced flushing at 10:30 p. m., continuing until 7 a. m. the following morning. Flushers were operated every night except Sunday.

In order to reduce non-productive travel to a minimum and enable the flushers to cover as much territory as possible it was found advisable to house the machines in separate sections of the city, the north, south and west sides. Suitable quarters were provided in ward yards most centrally located to the section wherein the machine operated. Owing to the necessity of covering as much territory as possible scheduled streets were covered every second day or night. The main arteries leading into the business section were covered nightly, as also were the streets within the business section. The benefits derived from the operation of the automobile flushers were most apparent. On streets not covered by the automobile flushers the displacement of air caused by rapidly moving automobiles or street cars would invariably raise a cloud of dust, whereas on streets that were flushed this condition was almost entirely eliminated.

It is believed that one of the principal factors in keeping down the cost of flushing was the installation of service recorders on these machines. These instruments allow no time to be lost without a proper explanation, thus preventing the idling of time by the operators.

The following account of operations is taken from the recently issued report of the Department of Public Works of Chicago:

During the period between April 10, 1915, and Nov. 19, 1915, 9,939.52 miles of streets were flushed, with a total of 271,407,644 sq. yd. cleaned, divided as follows:

| | Lin ft. | Sq. yd. | Cost. |
|---|---|---|---|
| North side | 19,213,606 | 96,961,529 | $ 3,303.45 |
| South side | 16,248,540 | 93,404,220 | 3,375.15 |
| West side | 15,491,575 | 73,543,171 | 3,161.87 |
| Loop district | 1,525,976 | 7,768,661 | 946.40 |
| Totals | 52,479,696 | 271,407,644 | $10,786.87 |

Material used in this work:
12,547 gal. gasoline.
572 gal. cylinder oil.
642 lb. medium cup grease.
39,297 tanks of water were used, equivalent to 58,990,500 gal., or an average of 5,865 gal. of water per mile of street flushed.

The working hours are accounted for as follows:

| | Hours. |
|---|---|
| Productive hours | 7,745.08 |
| Non-productive hours | 435.01 |
| Time lost (all causes) | 1,356.45 |
| Total | 9,536.54 |

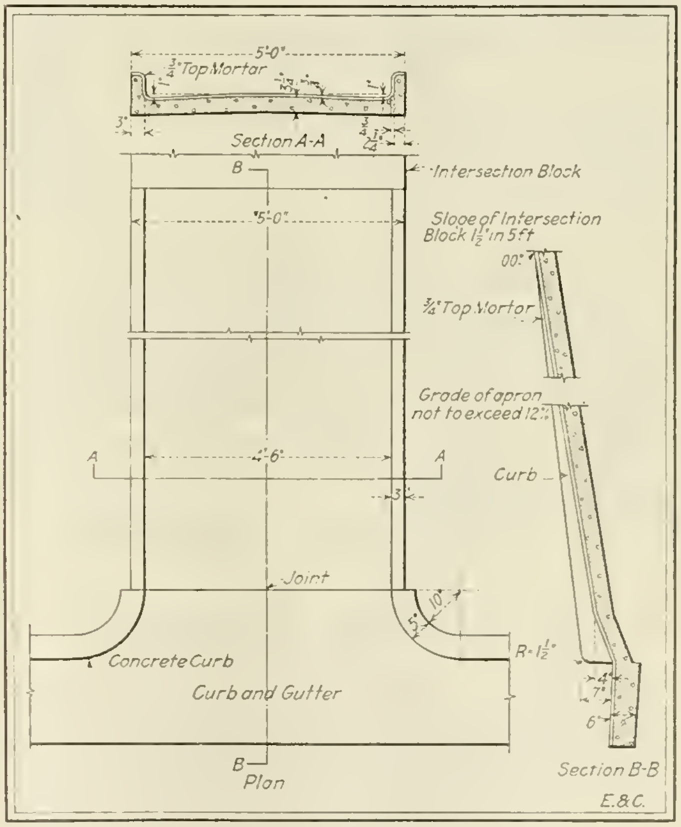
Efficiency, 83⅓%.

| | |
|---|---|
| Total cost of operation including percentage of salary of head motor truck driver | $11,209.87 |
| General average cost of flushing 1,000 sq. yd. | .041 |
| General average cost of flushing per mile | 1.13 |

## CONCRETE APRON FOR STREET INTERSECTIONS.

An interesting type of concrete sidewalk apron for use at street intersections where pavements have been laid, has been designed by F. C. Lohmann, City Engineer, of Champaign, Ill. The accompanying illustration shows a plan and cross-section of the "apron."

In the last four years the city has been removing the raised crossings in its pavement. This left a step of 7 in. at the gutter line. Since starting this practice, every year brought more complaints from the public, so the city officials began to look for some means of overcoming the lack of a raised crossing and still leave the paved portion of the street in a condition that vehicles might use any part of it with safety and comfort. As a result the "apron" was designed, and seems to be giving general satisfaction.



Plan and Cross Section of Sidewalk Apron.

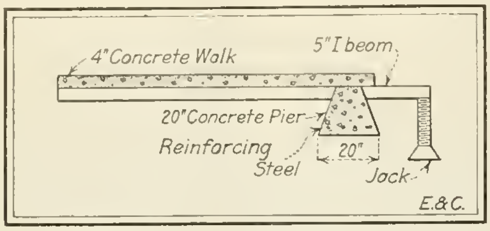
**Street Cleaning by Flushers at Chicago.**—During 1915 127,193,290 sq. yd. of streets of Chicago were cleaned by horse-drawn flushers. In this work 82,330,550 gals. or 154,438 tanks of water were used. The total cost of the flushing was $19,057 or 15 ct. per 1,000 sq. yd.

## METHOD AND COST OF RAISING SUNKEN CONCRETE WALK.

Contributed by H. R. Ferris, Victoria, B. C.

In the course of some construction, connected with street widening improvements, it was found necessary to raise to its original level 240 ft. of concrete walk which owing to defective earth foundation had sunk 5 or 6 in. on the outside edge. The walk was 12 ft. wide, 4 in. thick, with a mesh reinforcement, and although over 15 years old was still in perfect condition. It was possible that its settlement had been foreseen by the constructors, as 5-in. "I" beams had been placed cross-wise underneath it, at intervals of 8 ft.

In order to make room for a granite curb, the "I" beams which projected beyond the edge of the walk, were cut by hand with a hack-saw. The labor cost of cutting these I-beams was 48 ct. each. A concrete pier (see sketch) was placed under the outside edge of the walk after it had been raised to its original position. Twelve jacks were used for the work. The costs follow:



Method of Supporting Walk.

| | |
|---|---|
| Labor— | |
| Foreman, 3 days @ $4 | $12.00 |
| Labor raising walk, 112 hr. @ 30 ct. | 33.60 |
| Labor concreting, 56 hr. @ 30 ct. | 16.80 |
| Labor cutting "I" beams (30), 48 hr. @ 30 ct. | 14.40 |
| Labor on forms, reinforcement, 14 hr. @ 30 ct. | 4.20 |
| | $81.00 |
| Materials— | |
| Cement, 16 bbl. @ $2 | $32.00 |
| Sand, 6½ cu. yd. @ $1 | 6.50 |
| Gravel, 13 cu. yd. @ $1.10 | 14.30 |
| Hack saw (frame and blades) | 3.50 |
| Reinforcing steel, 500 lb. @ 3 ct. | 15.00 |
| Renting jacks | 6.00 |
| | $77.30 |

## ROCK PAVED FORD STREAM CROSSING.

In certain sections of Utah, where road building is difficult on account of the general ruggedness of the country, and where the people are scattered and funds are scarce, bridges are usually out of the question for spanning the smaller streams. The accompanying illustration shows a method adopted by the State Road Commission for furnishing transportation facilities across a broad wash in Washington County. This rock paved ford and retaining wall was constructed over "Two and Half Sandy" Wash. The stone was obtained on the site and was laid in place with cement mortar. The total width of the wash from bank to bank is 110 ft. The 40-ft. approaches on a 10 per cent grade also were paved with stone. The ford, according to the recently issued Third Biennial Report of the State Road Commission, from which this note has been taken, has given excellent satisfaction. E. R. Morgan, Salt Lake City, Utah, is Secretary-Engineer of the Commission.

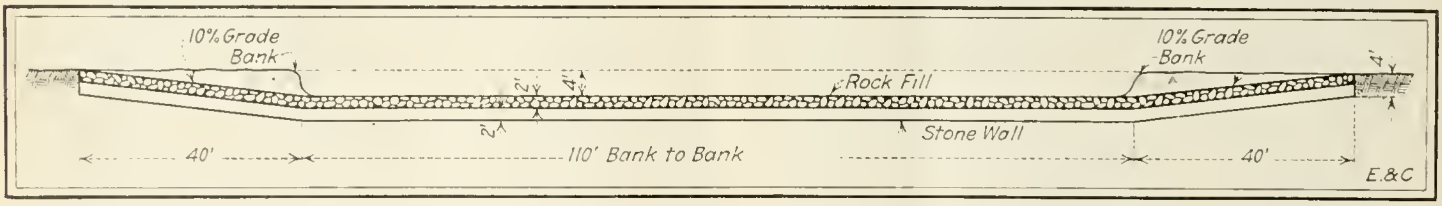


Fig. 1—Longitudinal Section of Rock Ford in Washington County, Utah.

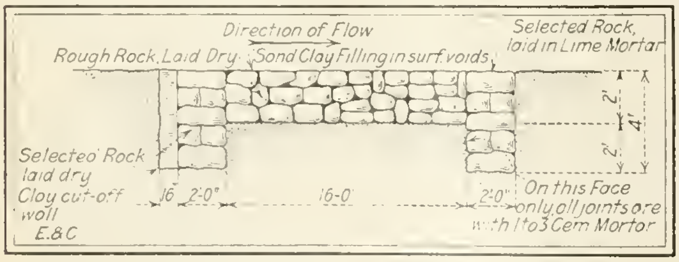

Direction of Flow
Rough Rock, Laid Dry
Sand Clay Filling in surf. voids
Selected Rock, laid in Lime Mortar
2'
4'
2'
Selected Rock laid dry
Clay cut-off wall
16
2-0"
16-0
2'0"
On this Face only all joints are with 1 to 3 Cem Mortar
E.&C

Fig. 2—Cross Section of Ford.

## EARTH ROAD MAINTENANCE IN HOPKINS COUNTY, KENTUCKY.

Hopkins county, Kentucky, has a considerable mileage of earth roads, which are kept in excellent condition by a system of maintenance by split log drags. The following description of this system is taken from the recently issued biennial report of the State Department of Public Roads:

Previous to 1911 the county roads were in charge of a road supervisor, who authorized the expenditure of a county road fund. Seven or eight grader outfits were employed for eight or nine months during the year. County warrants were issued, with no method of adequate bookkeeping to show the expenditures, and as a result the road fund yearly was overdrawn and the deficiency taken from other county funds. Later split log drags were substituted for the grader, or road machine crews. In 1912 a county engineer was appointed, replacing the road supervisor. The county roads, under his direction, were measured and 2-mile sections designated, and in January, 1913, drags were started on about 100 miles of the county roads. This original contract was only for dragging the road, which was to be done four times between Jan. 1 and April 1, at a cost of $10 to $12 per mile. As the sections dragged were not continuous the citizens at once appreciated the difference between the maintained road and the road that was not maintained. Consequently the next contract which called for dragging and cleaning of ditches for 6 months, until November, 1913, resulted in contracts for 150 miles of road and at a reduced cost.

In November, 1913, a contract substantially like that now in use was adopted and the time of the contract was for one year, or until November, 1914. Over 200 miles were maintained this year at an average cost of $28 per year per mile.

For the year, November, 1914, to November, 1915, the benefit of the maintained roads was so well appreciated by the citizens that 560 miles were under contract at an average cost of $24.35 per mile per year.

In November, 1915, a two-year contract was entered into, which the county may revoke for non-performance of the obligation at the end of the first year. About 520 miles are now under contract, at prices ranging from $12 to $40 per mile per year, and the average cost of $22.10 per mile per year. It is expected this mileage will soon be increased. Originally a contractor was allowed to have charge of 8 miles, but now he is not allowed to contract for more than 4 miles of road.

Under the 1915 contracts the contractor must trim the branches which overhang and interfere with travel on the roadway; keep the roadway between ditches free from shrubbery and weeds; keep the ditches clean, free of obstructions and at all times capable of carrying the water. He shall, "by June 1st each year, grade the roads with dump scraper and grader, drag and ditcher, or in any way he may see fit, so that the center of the roadway shall be crowned so that the water will flow from the center of the road to the side ditches, and at no place will the water stand on the road or run down the road. The road shall be dragged from ditch to ditch at each dragging, when the road is wet, but not sticky."

A record of the number of draggings is kept by the county engineer on cards, which before mailing by the contractor, are countersigned by the rural route carrier, or a reliable citizen. The contractor also hauls material and constructs all culverts and bridges of 10-ft. span or under, and keeps the approaches to and the floors and abutments of all bridges and culverts on his road in good traveling condition.

An analysis of these contracts shows that where the contract has been faithfully executed there is a decrease each year in the cost per mile, mainly because the farmer-contractor has learned from experience that continuous maintenance makes a lower cost of time and labor each succeeding year.

The benefits derived from this system are great improvements in the traveled ways and at a reasonable cost, and the repairing of all the roads throughout the county at practically the same time. The work is done by the farmer at a time when he could not be busy on the farm. The necessary equipment is usually made by the farmer-contractor and he is paid for his labor in November, just before his taxes are due. Each contract is usually adjoining the contractor's farm, and he has a personal interest in having his section well kept. The officials are beginning to appreciate the need of data regarding the width of surface maintained and the amount of traffic borne by the different roads, and no doubt in the near future will institute changes in the contract based on the width of surface and traffic conditions, which will again reduce the cost of maintenance and at the same time pay the contractor a more equitable price when compared with what the contractor on another road is doing for the payment made to him.

## COST DATA ON 1,170 SQ. YD. OF ASPHALTIC MACADAM BY DAY LABOR AT WAYNESBORO, PA.

Street improvements at Waynesboro, Pa., are carried out by the city street force under the supervision of Mr. G. C. Brehm, City Engineer.

The organization consists of two foremen at 21 ct. per hour, a roller engineer at 25 ct. per hour and labor at 18 ct. per hour.

Of the 25,000 sq. yd. of asphaltic pavements laid, one block (1,170 sq. yd.) was constructed on Cleveland Ave. The following data relate to the Cleveland Ave. work.

It was found upon examination that the old macadam was so badly worn that an entire new base was necessary, and in order to bring the contour of the road to its proper place, about 8 in. of grading had to be done, the rough grading being handled by means of the road roller and plow. The average haul was 1 mile.

Upon the thoroughly rolled sub-base, run of crusher limestone 6 in. thick after compression with a 10-ton roller, was used as a base.

Three inches of crushed stone (after compression) 2 to 3 in. in size was placed upon this base and after being thoroughly rolled with a 10-ton roller the asphalt, which was Aztec, was applied by means of pouring cans. Just enough ¾-in. stone to take up the voids was then spread over the hot asphalt and the whole was again thoroughly rolled. After applying ½ gal. of asphalt per square yard, the surface was covered with ½-in. chips and rolled.

The ¾-in. and ½-in. stone contained a great deal of dust and screening was necessary before they could be applied to the road. The cost of the work was 85 ct. per square yard, as follows:

GRADING (312 CU. YD.).

| Unit. | Amount. | Rate. | Total. | Per sq. yd. |
|---|---|---|---|---|
| Teams | 122 hr. | $0.05 | $ 61.00 | $0.0522 |
| Labor | 50 hr. | .21 | 10.50 | .0088 |
| Labor | 332½ hr. | .18 | 59.85 | .0514 |
| Roller engineer | 21 hr. | .25 | 5.25 | .0044 |
| Insurance | ... | .... | 1.56 | .0013* |
| Supervision | ... | .... | 14.00 | .0119 |
| Coal | 2,465 lb. | 4.50 | 5.55 | .0048 |
| Oil | 1 gal. | .50 | .50 | .0004 |
| Dep. machinery | ... | .... | 21.00 | .0179 |
| Total | | | | $0.1531 |

*Rate, $1.74 per $1,000.

BASE, 6 IN. (1,170 SQ. YD.).

| Unit. | Amount. | Rate. | Total. | Per sq. yd. |
|---|---|---|---|---|
| Stone | 250 tons | $0.75 | $187.50 | $0.1603 |
| Hauling | 99 hr. | .50 | 49.50 | .0423 |
| Spreading | 108 hr.* | .... | 20.19 | .0173 |
| Rolling | 7 hr. | .25 | 1.75 | .0015 |
| Coal | 828 lb. | 4.50 | 1.86 | .0015 |
| Oil | ¼ gal. | .... | .13 | .0001 |
| Supervision | ... | .... | 7.00 | .0060 |
| Insurance | ... | .... | .50 | .0004 |
| Dep. machinery | ... | .... | 7.00 | .0060 |
| Total | | | | $0,2354 |

*25 hours at 21 ct.; 83 hours at 18 ct.

SURFACE, 3 IN., OF 3-IN. AND 2-IN. STONE (1,170 SQ. YD.).

| Unit. | Amount. | Rate. | Total. | Per sq. yd. |
|---|---|---|---|---|
| Stone | 164 tons | $0.75 | $123.00 | $0.1051 |
| Hauling | 65 hr. | .50 | 32.50 | .0280 |
| Spreading | 116 hr.* | .... | 21.78 | .0186 |
| Rolling | 11 hr. | .25 | 2.75 | .0023 |
| Coal | 1,291 lb. | .... | 2.90 | .0024 |
| Oil | ½ gal. | .... | .25 | .0002 |
| Supervision | ... | .... | 11.50 | .0096 |
| Insurance | ... | .... | .61 | .0005 |
| Dep. machinery | ... | .... | 11.00 | .0094 |
| Total | | | | $0.1763 |

*30 hours at 21 ct.; 86 hours at 18 ct.

ASPHALT.

| Unit. | Amount. | Rate. | Total | Per sq. yd. |
|---|---|---|---|---|
| Asphalt* | 2,381 gal. | $0.08½ | $202.39 | $0.1729 |
| Hauling | 37 hr.† | .... | 8.58 | .0073 |
| Applying | 128 hr.‡ | .... | 23.88 | .0204 |
| Wood | 3 cords | 4.00 | 12.00 | .0103 |
| Oil and waste§ | ... | .... | 2.19 | .0019 |
| Supervision | ... | .... | 3.50 | .0029 |
| Insurance | ... | .... | .58 | .0005 |
| Dep. machinery | ... | .... | 3.00 | .0026 |
| Total | | | | $0.2188 |

*Aztec. †6 hours at 50 ct.; 31 hours at 18 ct. ‡28 hours at 21 ct.; 100 hours at 18 ct. §12 gal. oil at 12 ct.; 5 lb. waste at 15 ct.

STONE, 1 IN. AND ¾ IN.

| Unit. | Amount. | Rate. | Total. | Per sq. yd. |
|---|---|---|---|---|
| Stone | 15 tons | $0.75 | $ 11.25 | $0.0096 |
| Hauling | 13 hr. | .50 | 6.50 | .0056 |
| Spreading | 17 hr.* | .... | 3.18 | .0027 |
| Screening | 23 hr. | .18 | 4.14 | .0035 |
| Rolling | 4 hr. | .25 | 1.00 | .0009 |
| Coal and oil† | 468 hr. | .... | 1.11 | .0009 |
| Supervision | ... | .... | 3.50 | .0030 |
| Insurance | ... | .... | .21 | .0002 |
| Dep. machinery | ... | .... | 4.00 | .0034 |
| Total | | | | $0.0298 |

*4 hours at 21 ct.; 13 hours at 18 ct. †Oil, ⅛ gal.

STONE, ½ IN.

| Unit. | Amount. | Rate. | Total. | Per sq. yd. |
|---|---|---|---|---|
| Stone | 6 tons | $0.75 | $ 4.50 | $0.0038 |
| Hauling | 7 hr. | .50 | 3.50 | .0030 |
| Spreading | 11 hr.* | .... | 2.04 | .0018 |
| Screening | 11 hr. | .18 | 1.98 | .0017 |
| Rolling | 4 hr. | .25 | 1.00 | .0009 |
| Coal and oil† | 468 lb. | .... | 1.11 | .0009 |
| Supervision | ... | .... | 3.50 | .0030 |
| Insurance | ... | .... | .15 | .0001 |
| Dep. machinery | ... | .... | 4.00 | .0034 |
| Total | | | | $0.0186 |

*2 hours at 21 ct.; 9 hours at 18 ct. †Oil, ⅛ gal.

MISCELLANEOUS.

| Unit. | Amount. | Rate. | Total. | Per sq. yd. |
|---|---|---|---|---|
| Teams | 21 hr. | $0.50 | $ 10.50 | $0.0089 |
| Labor | 49 hr.* | .... | 9.24 | .0079 |
| Blacksmith, repairs, etc. | ... | .... | 1.50 | .0013 |
| Total | | | | $0.0181 |

*14 hours at 21 ct.; 35 hours at 18 ct.

SUMMARY.

| | Per sq yd. pavement. |
|---|---|
| Grading | $0.1531 |
| Base | .2354 |
| 3-in. surface | .1763 |
| Asphalt application | .2188 |
| Stone, 1-in. and ¾-in. | .0298 |
| Stone, ½-in. | .0186 |
| Miscellaneous | .0181 |
| Total | $0.8501 |

## A NEW METHOD OF FINISHING CONCRETE ROADS.

Finishing concrete roads by dragging heavy belting across the surface has recently been tried out in Wayne county, Michigan, where the method of using the belt is as follows: Three pieces of heavy belting about 10 in. wide and cut a few feet longer than the width of the road are used. The first is seesawed across the road as soon as the template has been used. The second belt is used in a similar manner but not until water has just disappeared from the surface. After the concrete has stiffened somewhat, the third belt is run over the surface and leaves a fine grained, coarse, gritty texture.

On the Fremont-Port Clinton Road in Ohio contractors are using a strip of 8-ounce canvas 24 in. wide and 18 ft. long in much the same manner.

These finishing methods are apparently outgrowths of one practiced in California where a strip of pliable redwood ⅜ in. thick, of suitable width, has been used to finish a concrete road surface. It is stated that while the value of these methods has not been demonstrated beyond dispute, indications are that they will prove to be more economical and satisfactory than hand floating.

## TELFORD STRIP FOR PREVENTING RUTTING.

In paving Harrison St. at Oshkosh, Wis., telford strips were placed between the pavement and the gravel shoulders, with the idea of preventing the formation of ruts at this point. The road bed was graded to a width of 26 ft., the gravel in the existing road being placed to one side for use in making the gravel shoulders. The center 14 ft. was paved with asphaltic concrete consisting of a 2-in. top on a 6-in. 1:3:6 concrete foundation. The curb was formed by building a 2-in. shoulder on the concrete foundation. Each curb was 6 in. wide, making the total width of the asphaltic concrete 13 ft.

On both sides of this center 14-ft. portion there was placed a strip of telford stone of an average width of 1 ft. The gravel shoulders were each 5 ft. wide. The telford strip was set alternately 8 in. and 16 in. wide so as to break joints. The stone was a hard limestone, 8 in. in height and at least 6 in. in width by 4 in. thick, laid by hand with the heavy end down. The stones were set plumb and close together. The interstices were filled with crushed stone or gravel and then tamped and rolled and filled with a cement filler composed of 1 part Portland cement and 2 parts coarse sharp sand.

The total cost of the 26-ft. roadway was 99.6 ct. per square yard. The work was done last year under the direction of Mr. George H. Randall, City Engineer.

## COST OF AUTOMOBILE TRANSPORTATION FOR THE HIGHWAY ENGINEER.

We are indebted to Mr. A. W. Allen of the Engineering Department of the California Highway Commission for the following data on the operating cost of a 1913 model, 5-passenger Ford touring car, covering the period from Oct. 3, 1913, to Aug. 3, 1916. The car was used by Mr. Allen as engineer on highway work in Southern California; one year on the coast and two years on the desert in the Imperial Valley. The original cost was $625 plus $85 for extras, making a total of $710. The present sale value is estimated at $150. The total mileage is 27,320. The front tires averaged 5,136 miles and the rear tires averaged 5,090 miles. The price of gasoline varied from 12 to 35 cts.

As the sale price of Ford automobiles has been reduced from $625 to $410 since 1913, a comparative statement of the operating cost on the basis of the reduced sale price is included. The operating cost for the period from Oct. 3, 1913, to Aug. 1, 1916, was as follows:

| Operating Cost: | Total cost. | Cost per mile. |
|---|---|---|
| Gasoline, 1,536 gal. | $ 293.86 | $0.01076 |
| 17.8 miles per gal.; av. cost, $0.191. | | |
| Oil and grease (55.6 gal. oil) | 39.05 | .00143 |
| 190 miles per gal. of oil. | | |
| Tires—Tubes and casings | 265.68 | |
| Repairs | 12.90 | .01020 |
| Repairs and renewals | 224.00 | .00820 |
| Lights | 13.10 | .00048 |
| Garage | 26.50 | .00097 |
| License, insurance and taxes | 58.63 | .00214 |
| Direct operating cost | $ 933.72 | $0.03418 |
| Depreciation, $710, less $150 | 560.00 | .02050 |
| Interest on investment at 7 per cent on $430 | 85.28 | .00312 |
| Total operating cost | $1,579.00 | $0.05780 |
| Operating cost on basis of present sale price of Ford, $410: | | |
| Direct operating cost | $ 933.72 | $0.03418 |
| Depreciation, $495, less $150 | 345.00 | .01263 |
| Interest on investment at 7 per cent on $322.50 | 60.22 | .00220 |
| Total operating cost | $1,338.94 | $0.04901 |

In a paper presented at the last annual meeting of the Iowa Engineering Society Mr. W. D. Maxwell gives the following data on the operation of a Ford car in connection with his work as County Engineer of an Iowa County. Mr. Maxwell states that a small amount of additional equipment should be added to the Ford as it comes from the factory, but there is no necessity for loading down the car with superfluous accessories. The extra radius rod trusses are a good investment from the standpoint of safety. All four wheels should be fitted with 3½-in. tires because of the great convenience of having all tires alike, and because the large tires in front wear longer. Some arrangement of straps or hoops alongside the body of the car is advisable for carrying long rods and other surveying apparatus. An electric starter is convenient but is not essential.

Mr. Maxwell is of the opinion that it is not economical for the county engineer to drive one car more than two seasons. At the end of that time the car should not be worn out by any means if it has been properly taken care of, and should have a good second hand value. However, it will have reached the point where considerable tinkering and more or less repairing is necessary, so that maintenance is much higher, and worse yet, the engineer loses valuable time. Consequently a comparatively new car is the cheapest. Under some conditions a new car each year may be most economical, but ordinarily a Ford will do fairly well for two running seasons.

The cost data in Table I, which have been carefully compiled, give a record of the performance of the same car during several seasons, and also affords a comparison between an old car and a new one. The figures are not intended to represent an unusual record, but simply to show how transportation has been obtained, under ordinary conditions for one county engineer.

TOTAL COST INCLUDING COST OF CAR.
Car No. 1.

| | |
|---|---|
| Complete new cost | $ 660.00 |
| Sold second-hand for | 200.00 |
| Net cost | $ 460.00 |
| Total maintenance | 821.34 |
| Total | $1,281.34 |

or 6.34 ct. per mile for 20,195 miles.

## STONE BLOCK GUARD WALL.

In Switzerland many of mountain roads have guards made of concrete blocks or rough dressed stones placed at intervals of 2 ft. or 3 ft. This plan also is used in this country on many side hill roads. Sections of the Columbia Highway in the state of Washington, for instance, have a line of rough boulders on the embankment side. An example of a protective wall of this kind is given in the accompanying illustration. This shows the road leading from Lambertville, N. J. The blocks of stone are about 3½ ft. long and are imbedded about 1 ft. in earth. They are set 3 ft. apart.

Stone Block Guard Wall on New Jersey Road.

TABLE I—MAINTENANCE COST OF FORD CAR.

| Year. | Miles. | Gasoline Gals. | Gasoline Cost. | Oil Gals. | Oil Cost. | Labor on car. | New parts. | Tires Repairs. | Tires New. | Miscellaneous. | Total. | Per mile. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Car No. 1. | | | | | | | | | | | | |
| 1913 | 6,520 | 365 | $ 73.00 | 22 | $13.20 | $ 16.40 | $ 11.85 | $17.20 | $ 40.20 | $19.10 | $190.95 | $2.93 |
| 1914 | 10,107 | 598 | 96.80 | 59 | 35.32 | 111.45 | 91.76 | 17.60 | 57.45 | 14.10 | 424.48 | 4.20 |
| 1915 | 3,568 | 294 | 42 26 | 25 | 15.05 | 49 70 | 49.00 | 9.25 | 21.30 | 19.35 | 205.91 | 5.80 |
| Total | 20,195 | 1,257 | 212.06 | 106 | 63.57 | 177.55 | 152.61 | 44.05 | 118.95 | 52.55 | 821.34 | 4.05 |
| Car No. 2. | | | | | | | | | | | | |
| 1915 | 6,074 | 390 | 51.69 | 19½ | 11.55 | 5.45 | .10 | 4.80 | 27.00 | 5.45 | 106.04 | 1.75 |

## RULES AND REGULATIONS FOR CARRYING OUT THE FEDERAL AID ROAD ACT.

The Secretary of Agriculture early last month made public the rules and regulations for carrying out the Federal Aid Road Act. This act, it will be remembered, provides for an expenditure of $75,000,000 during the next 5 years for highway improvement purposes. The first appropriation of $5,000,000 for the fiscal year ending June 30, 1917, already has been allotted. Some of the regulations of particular interest to the engineer and the contractor follow:

### Surveys, Plans, Specifications and Estimates.

Surveys and plans shall show, in convenient form and sufficient detail, according to accepted engineering practice, necessary data, in connection with the specifications and estimates, to enable the secretary to ascertain and pass upon location, grades, drainage, bridges, other structures, special and unusual features, the work to be performed, and the probable cost thereof.

Specifications shall set forth the proposed method of construction, type of construction, materials to be used, and other essentials, in such detail as to afford complete knowledge of all steps to be taken in the construction of the project.

The estimate for each project shall show the estimated quantity and cost of each item of construction in detail and, separately, the 10 per cent fund, and shall not include any expense of advertising.

Rights of way necessary for any project shall be provided, and any incidental damages to adjoining property due to construction work paid, by or on behalf of the state, and the expense thereof shall not be included in the estimate or paid in any part, directly or indirectly, by the Federal Government.

Grade crossings shall be avoided where practicable. The estimated cost of eliminating a grade crossing shall not include any amount the state, county, or other civil subdivision has received, is to receive, or is entitled to receive, directly or indirectly, as reimbursement or payment from the owner of a public utility, for or on account of such elimination.

No part of the expense of making surveys, plans, specifications or estimates, by or on behalf of the state prior to the beginning of construction work, shall be included in the estimate or paid by the Federal Government.

When plans, specifications and estimates have been approved by the secretary, no alteration thereof shall be made without his approval.

For all projects for which statements are submitted after December 31, 1916, standards governing the form and arrangement of plans, specifications and estimates will be hereafter prescribed and promulgated by the secretary.

No part of the Federal money set aside on account of any project shall be paid until it has been shown to the satisfaction of the secretary that adequate means, either by advertising or by other devices appropriate for the purpose, were employed, prior to the beginning of construction, to insure the economical and practical expenditure of such money.

Immediately on publication of advertisements, copies thereof shall be furnished to the Office of Public Roads.

Bids shall be in such form that the unit prices at which the various services are to be performed, and the various materials furnished, will be clearly shown.

Copy of the tabulated bid prices, showing the unit prices and the totals of each bid for every project, shall be furnished promptly to the Office of Public Roads.

In advance of the acceptance of any bid, sufficient notice of the time and place the contract is to be awarded shall be given to the Office of Public Roads to enable it, if it so desire, to have a representative present. When a bid has been accepted prompt notice thereof shall be given to the Office of Public Roads.

If the contract be awarded to any other than the lowest responsible bidder, the Federal Government shall not pay more than its pro rata share of the lowest responsible bid, unless it be satisfactorily shown that it was advantageous to the work to accept the higher bid.

A copy of each contract as executed shall be immediately certified by the State Highway Department and furnished to the Office of Public Roads.

The specifications and plans shall be made a part of the contract.

No alteration in such contract shall be made without the approval of the secretary.

Suitable samples of materials to be used in construction work shall be submitted, by or on behalf of the State Highway Department, to the Office of Public Roads whenever requested.

Unless otherwise stipulated in writing by the secretary or his authorized representative, materials for the construction of any project shall, prior to use, be tested for conformity with specifications, according to methods prescribed, or approved, by the Office of Public Roads.

Unless otherwise specifically stipulated in the project agreement, bridges, viaducts and under-passes shall have clear width of roadway of not less than 16 ft., and clear head room of not less than 14 ft. for a width of 8 ft. at the center.

No part of the money apportioned under the Act shall be used, directly or indirectly, to pay, or to reimburse a state, county or local subdivision for the payment of, any premium or royalty on any patented or proprietary material, specification, process, or type of construction, unless purchased or obtained on open actual competitive bidding at the same or a less cost than unpatented articles or methods equally suitable for the same purpose.

The supervision of each project by the State Highway Department shall include adequate inspection throughout the course of construction.

Written notice of commencement and completion of construction work on any project shall be given promptly by the State Highway Department to the Office of Public Roads.

Reports of the progress of construction, showing force employed and work done, shall be furnished, from time to time, whenever requested by the secretary or his authorized representative.

Labor, teams, materials and equipment furnished, in lieu of money, by or on behalf of the State Highway Department on construction work shall be used only on such terms and conditions as are set forth in the project agreement.

### Records and Cost Keeping.

A separate account for each project shall be so kept, by or under the direction of the State Highway Department, as to enable the secretary, or his authorized representative, to ascertain at any time the expenditures on and the liabilities against the project and, separately, the condition of the 10 per cent fund.

Such other records of contract and force account work, and of inspections and tests by or on behalf of the state, shall be kept, by or under the direction of the State Highway Department, as will enable the secretary, or his authorized representative, at any time to determine the condition of the construction and maintenance of, and the cost to the state and the Federal Government of the construction work and labor done on, any project.

The accounts and records, together with all supporting documents, shall be open, at all times, to the inspection of the secretary, or his authorized representative, and copies thereof shall be furnished when requested.

Certified copies of payrolls on force account work and of all vouchers for other expenditures shall be furnished, whenever requested by the secretary or his authorized representative.

Whenever requested by the secretary or his authorized representative, unit costs on any project shall be kept, on forms furnished by the Office of Public Roads.

## FACTORS AFFECTING THE STRENGTH AND PROPORTIONING OF GRAVEL CONCRETES.

Contributed by R. J. Borhek, Tacoma, Wash.

From the results of the investigations of the Bureau of Standards on the strength of concretes and mortars and the many private investigations for strength and properties of the aggregates the writer would call to the attention of those interested the salient facts affecting the strength and proportioning of sand gravel concretes.

This paper of necessity deals with the local aggregates as regards quality and the few general remarks contained regarding density, consistency and protection will apply equally as well to the study of any concrete aggregate.

The aggregates need be considered for quality, size and shape insomuch as there are vast differences in the physical qualities and composition of all sands and gravels. In the comparison of aggregates of like character, quality has a greater influence on the strength than would size or shape.

The mineral constituents of a rock determine the durability to a marked extent; if the rock is made up of hard minerals not easily soluable it will afford good gravel. The softer and easily soluble minerals found in sedimentary and metamorphic rocks of schistose structure decrease the resistance to compressive strength, shearing, abrasion and toughness. Fineness of grain and density of structure will influence the physical qualities to a considerable extent and are probably the chief characteristics of a good concrete gravel.

It would be difficult to classify the local gravels on account of the variability of the physical properties as the rocks of the same type having the same mineral composition are in all stages of alteration due to heat, pressure and different rate of cooling, etc. Atmospheric weathering as well as the influences of chemical changes affect the physical properties of the rock. The greater proportion of the local gravels are of igneous origin and of coarse-grained crystalline structure formed by slow cooling at a distance below the earth's surface.

The igneous volcanic rocks present are of finer grain and texture having been expelled either by eruption or flow and subjected to more rapid cooling. Of the first class the igneous granitic rocks, which form probably 40 per cent of the local gravels and are generally of intermediate size, are not as hard, tough or as resistant to abrasion as the finer grained small sized pebbles of purely volcanic origin.

The preponderance of silicate minerals in the igneous rocks offer great resistance to weathering with a consequent degree of hardness exceeding that of sedimentary and most metamorphic rocks.

The basalts, diabase, andesite and rhyolite pebbles of the igneous volcanic variety when fresh and in an unaltered state are excellent concrete stone. The basalts and diabase pebbles are superior to the porous and lighter andesites and rhyolites of the local deposits, the latter two often contain much rock glass and are uneven in texture and hardness due to alterations in structure.

The diorites and gabbros intermediate between the granitic and volcanic pebbles are generally very hard and highly resistant to crushing, although containing less quartz or silica than do any other rocks of this class.

The influences of glacial abrasion is very marked with rocks of different type, the shapes varying from almost perfect roundness to flat, angular pebbles with sharp edges.

The granitic pebbles are more round and of more even texture than the other igneous rocks except where an abundance of mica or altered feldspar is present. The specific gravity of the granitics average 2.67.

The basalt and diabase pebbles are sub-rounded to angular with rounded edges and show an even wear, fine texture and sharp fracture. The basalts are variable in hardness and appear to have been subjected to considerable weathering, also structural changes due to high degree of fusion. The basalts and diabase pebbles are high in gravity, ranging from 2.69 to 2.85.

The andesites and rhyolites are generally the largest sized pebbles found in the local deposits, are rounded to sub-rounded in shape, porous and easily detected by the rough surface and irregular hardness. The altered structure of the pebbles, together with the uncertainty as to hardness make them poor concrete stone. The specific gravity varies from 2.50 to 2.68; the higher gravity given by the fresher rocks.

The metamorphic rocks, of which there are possibly 30 per cent present, are, as a rule, of good quality, include the granite-gneiss, white and green quartzites and a scattering of schists. Excepting the schists the pebbles are rounded to sub-rounded and of excellent quality, hard and durable and as a result should be highly resistant to wear. The high percentage of silicate materials present in the quartzites denote great crushing strength. The specific gravities range from 2.65 to 2.70. The scattering of schistose pebbles even though high in gravity are low in strength, due to a foliated structure and the presence of much mica and altered feldspar. The pebbles assume an angular and slabby appearance, have sharp edges and splintery fracture, making them unfit for concrete aggregate.

The sedimentary rocks are almost entirely absent in the Steilacoom gravels; the few present are of good quality, particularly the close grained sandstones and cherts. The sandstones are angular to sub-angular, while the cherts are well rounded and of smaller size. These rocks denote great crushing strength and would probably be highly resistant to wear. They range from 2.55 to 2.70 in gravity.

The pebbles expelled by volcanic action found in some of the deposits are very porous, soft and of such poor quality that they can readily be ground underneath the heel. The pebbles can easily be detected by their light gravity and variegated coloring.

The range in quality of the local gravels, considering the entire Puget Sound Region, would probably show a difference of several hundred per cent in strength as concrete aggregate.

Bureau Standards Bull. No. 58 shows range from 888 lb. to 4,100 lb. in compressive strength for 1-2-4 concrete at 28 days for the eleven samples tested.

Size and shape of the gravel will affect the density of a considerable extent and as a result have a direct bearing on the compressive strength, although not to the extent as affected by the quality of the aggregate. The effect of the size of coarse particles has been determined within certain limits, and it appears that the larger the aggregate the greater the strength of the concrete on account of the displacement of the finer particles by the coarse allowing an excess of mortar. Within the limits of the mix for maximum density additional coarse aggregate can be used to great advantage, especially in the rich proportions. Too lean a mixture and a sloppy consistency will cause honeycombing by the use of too great a proportion of the larger sized aggregate.

Conclusions regarding the effect of shape of particles are more difficult to understand. The chief difficulty appears to be to determine the effect of shape when combined with the sand. Rounded and angular, sub-rounded and sub-angular particles appear to be equally as effective in producing dense concrete and no particular shape of particle seems to give the greatest density or strength.

In general the more rounded the gravel the denser the gravel, the sub-rounded or sub-angular particles will have a higher void content and yet yield as strong a concrete when mixed with the same sand and cement. To what extent shape of particles affect the strength of the sand, gravel cement mixture would bear much investigation.

The roughness or smoothness of the pebble would undoubtedly have considerable influence on the wedging action of the sand grains holding apart the coarse aggregate; to what extent this would be neutralized by a water film in lubricating the surfaces is not known.

In quality sands are directly comparable to gravels, the better quality affording the greater strength.

The size of sand grain that will best combine with a given gravel is as yet unknown. As a broad general statement a coarse sand combines best with a coarse gravel and a fine sand combines best with a fine gravel.

The tests recorded in Bull. No. 58, Bureau of Standards were made with sands considerably finer than the local sands and gave excellent results. In fact the results obtained do in some instances exceed the strengths of the best coarse and well graded sand gravel mixtures of local use.

Quoting from Bull. No. 58, Standards Bureau:

"Contrary to general practice and opinion the relative value of several fine aggregates to be used in concrete cannot be determined by testing them in mortar mixtures. They must be tested in the combined state with the coarse aggregate.

"Contrary to general practice and opinion the relative value of several coarse aggregates to be used in concrete cannot be determined by testing them with a given sand in one arbitrarily selected proportion. They should be tested in such combination with the fine aggregate as will give maximum density, assuming the same ratio of cement to total combined aggregate in all cases."

The few compressive tests of the local aggregates in which the proper data has been recorded readily bear out the above statements.

The percentage of voids and the absorptive quality of the aggregates are important in controlling the consistency of the mixture.

The consistency has considerable influence of the ultimate strength and as such is next in importance to the quality of the aggregate.

The aggregates are generally free from any injurious internal changes due to the addition of water and cement except that the high degree of absorption of a weak aggregate under marked temperature change might seriously affect the strength.

Gravel and sand usually require less water in mixing than do crushed rock and screenings, due to the lower voidage in the sand gravel mixture. The Steilacoom sands and gravels are so nearly constant in absorption that no considerable difference in consistency would occur should we neglect absorption entirely.

There is a vast difference in the amount of water the sands will retain at complete saturation, and as a consequence concrete of varying consistency with the resulting honeycombing, laitance, separation and other evils of the much abused and little understood structural material are allowed to multiply.

At complete saturation the local sands will retain from 11 to 16 per cent of moisture by weight.

Measured in pounds or gallons the amount of water for sand cement mortars will vary 3 per cent for like consistency; this variation is due to the difference in fineness, coarseness and graduation of the particles. The coarse sands with low voidage require less water and usually show the highest strength in mortars, but not by any means the strongest when combined with the coarse aggregate in concrete.

The amount of water used in gauging our local cements will vary 20 per cent for mortars of like consistency, with an average variation of 10 per cent for the three cements in most common use.

Consistency of the mixture, in other words the amount of water to use to mix concrete is probably as important as the amount of cement used.

Bull. No. 58 shows a variation of 200 to 300 per cent in the compressive strength, due to variation of 10 to 20 per cent in the amount of water used.

The Bulletin states in conclusion: "The compressive strength of concrete may be reduced by the use of an excess of water in mixing to a fractional part of that which it should attain with the same materials. Too much emphasis cannot be placed upon the injurious effect of the use of excessive quantities of water in mixing concrete."

In the light of long time tests (up to 3 years) the prevalent idea that an excess of water causes the ultimate strength to be retarded during the early periods, the following is offered for a somewhat extended investigation:

Tests of "The Effect of Excess Mixing Water on 1-2-4 Concretes," by Board of Water Supply, New York City. The aggregates were granite and limestone with natural screenings from the coarse aggregates. Water reduced from 10 per cent to 8.5 per cent. Three months, 10 per cent decrease; 1 year, 15 per cent decrease; 2 years, 20 per cent decrease; 3 years, 40 per cent decrease.

Method and time of mixing play an important part in the quality of the product. The time of mixing is influenced by the amount of water used as well as by the efficiency of the mixer. Excessive mixing with excessive water appears to decrease the strength; the same is noted with excessive water and insufficient mixing. Excessive mixing with minimum water will yield strong concrete.

With some cements the mixing time could be continued beyond the period of initial set and an excellent result be had. In fact this has been done in many instances and a product of excellent quality obtained. In this process the retention of enough water to effect proper hydration is vital and some means should be taken to prevent rapid evaporation.

The effect of moisture content is more marked with the sand than with the gravel, due to the great number of fine particles in the sand as compared with the gravel. This difference in moisture content may cause a difference of 15 to 20 per cent of the amount of water used in gaging and is one of the chief difficulties of proper proportioning.

Increasing the amount of water will increase the volume or bulk of the sand up to a certain point; an additional increase in moisture will cause the sand to decrease in volume. Increased volume or bulk means increased voids. At complete saturation the bulk, volume or voidage decrease to about the original value. Handling the sand will cause a re-arrangement of particles and result in a different degree of compaction influencing the void content.

A study of sand-gravel-cement-water mixture at this stage of the manufacture would undoubtedly reveal some interesting facts.

A study of the sands to determine at what degree of saturation dispersion occurs would be of value in determining the proper amount of water to use in mixing.

Some means of controlling the moisture or having the sand at a constant state of saturation would seem advisable.

In checking the amount of water used in mixing, the writer has never been able to find less than 9 per cent of water in use except in hand mixed, hand tamped sidewalk work where it was essential that the topping could be placed immediately. The customary practice for street paving has been from 10 to 10.5 per cent water and for building construction 10 to 12 per cent with the use of local aggregates. The use of 8 to 8.5 per cent water will allow spouting with most any well balanced mix of the local aggregates.

As the water content is best expressed as a per cent of the total weight of the dry materials some means of weighing a constant volume of the materials at a constant degree of compaction with a known moisture content would appear practicable for proportioning. Probably some mechanical means of controlling the consistency could be devised rather than have the attendant use "eye judgment" when charging the mixer.

Experiments are now being conducted to eliminate all water except that necessary to effect proper hydration and combine the aggregates. The work thus far carried on tends to show excellent results as regards density.

The many suggestions regarding proportioning are as yet unsatisfactory in that the maximum strength is not obtained by any fixed rule, the variables, size and shape of aggregates, degree of compaction and moisture are so elusive that the many refinements called for in practice are oftentimes of no value. Void proportioning without knowing range in compaction of the aggregate will yield concrete of varying density and strength. Loose voids, medium compact and compact voids will cause a variation in the weight per cubic foot of the dry local aggregates as much as 20 per cent. A sand having 27 per cent voids in a compacted state will show 39 per cent loose. The true voidage under working condition will be about 33 per cent. The total weight of the sand gravel mixture compacted by shaking may be 141 lb. per cu. ft., the total amount of other ingredients, cement and water, contained in 1 cu. ft. of concrete an additional 35 lb., theoretically a total of 175 lb., the concrete will weigh under the best conditions about 156 cu. ft. There is unquestionably some great deficiency between the theoretic ideal and the practical result.

Density appears to be one of the controlling factors required for greatest strength, and in the many tests illustrated in Bull. No. 58 in the majority of cases maximum density gave maximum strength.

Maximum strength for the rich mixtures appears to be obtained by arbitrary proportions, without regard for the proportions for maximum density. In the lean mixtures this is not as noticeable as the amount of cement used is in a great measure the index to the strength, and we approach the cement carrying capacity of the sand by "thinning out" the cement.

It has been well established that there is a definite relation between the compressive strength and the amount of cement to total aggregate; with the relative amount of fine and coarse aggregate fixed the richer the cement content the greater the strength.

In the rich mix, 1 to 6, the percentage of coarse aggregate material passing the ¼-in. screen may be as high as 20 per cent, with very little resulting loss in strength. This loss is more noticeable in the leaner mixes; when there is a large proportion of sand in the coarse aggregate too great a burden is placed on the cement.

How best to obtain concretes of maximum density and strength would require the testing of all available aggregates in differing proportions of fine to coarse and incorporating them in the work in the proportion thus fixed upon. It might be possible to test the dry aggregate together with the cement and obtain results directly comparable with the concrete made therefrom.

Impermeable concretes, such as are used in bridge piers abutments, sea walls or works of like character, even though very dense are not necessarily the strongest that could be made with the given materials. Where the sand is too coarse the addition of sufficient fine material will yield impermeable concrete. This important fact is too often neglected and impermeability is unwittingly sacrificed for strength where the additional strength is not needed.

Consistency of the mixture appears to play an important part in obtaining density, the lower the water content the greater the density. This holding true to a point where the minimum amount of water will just yield a quaking mix. There appears to be some critical point at which the water is most effective in yielding concretes of greatest strength and density.

The extreme density of bituminous paving mixtures is undoubtedly due to the absence of water. A mixture wherein a well graded mineral aggregate is bound together by bitumen and compressed. The plastic semi-fluid mass in many cases shows but 2 per cent voids in the finished paving. Concrete on the other hand will show under present methods a probable minimum of 6 per cent voids. It would appear that the nearer we could approach the conditions of the paving mix using cement as a paste the better would be the result.

Tamping is undoubtedly of great benefit and should be resorted to wherever possible. The final mixing and consolidation due tamping, together with the necessary decrease in water content to effect proper tamping, will yield concrete of greater strength and density than would otherwise be possible. Tamping has proven to be one of the most effective ways to prevent arching and reduce water and air voids.

About 7 per cent of water to total weight of dry materials is best suited for tamping consistency with the local aggregates.

Atmospheric conditions during curing, together with proper protection, will influence the strength to a considerable extent. The retention of the proper amount of water to effect proper hydration is of much importance in obtaining concrete of good quality.

The gain in strength of properly cured concrete would more than compensate for the cost of continual wetting down; this is too often neglected in building construction.

The commendable work of the Bureau of Standards will have a lasting influence in disabusing our minds of arbitrary standards and enlighten the concrete worker as to the reason of his failures.

In every locality a systematic series of investigations together with compressive tests should be made. This would of necessity be a public work and should be taken up as such by the state or city officials in charge of public works. The results would be of inestimable value in affixing proper standards and affording knowledge as to the relative value and proportions of any given aggregate. Just how many millions of dollars are wasted annually by the improper use of concrete time alone will tell.

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## SOME ENGLISH COSTS ON THE COLLECTION OF REFUSE BY ELECTRIC VEHICLES.

The town of Nottingham, England, during the past year has used electric vehicles for the collection of refuse. These motors are equipped with Edison storage batteries. The following figures on the cost of operation are abstracted from a paper presented at the last annual conference of the Institute of Cleansing Superintendents, by J. Terry, cleansing superintendent, Nottingham:

During six months ending July 1, 1915, the cost of emptying dry ashbins by horse vehicle in Nottingham averaged 4s. 4d. per ton, but owing to the increased charges for horse-keep, wages, etc., the cost is now 5s.

The No. 1 motor was delivered on Oct. 15, 1915, commenced work on the 18th, and has been in use daily ever since. During the six months ending April 15th it carried 422 loads, weighing 1,288 tons, at a cost of *£241 13s. 14d., which is equal to 3s. 9d. per ton, the average weight per load being 3.05 tons.

The costs are made up as follows:

| | £ | s. | d. |
|---|---|---|---|
| Depreciation at 10 per cent | 52 | 13 | 0 |
| Insurance | 4 | 5 | 0 |
| Oil, water, repairs, etc. (allowed) | 11 | 9 | 8 |
| Tires, 1,819 miles at 1.1d | 8 | 6 | 9 |
| Current, 2,541 miles at 1¼d | 13 | 4 | 8 |
| Wages | 151 | 14 | 9 |
| | £241 | 13 | 10 |

For the six months ending July, 1916, 1,167 tons of refuse were removed, at a cost of £253, or 4s. 4d. per ton, which is exactly the same as the cost of horses, as mentioned above; but it must be remembered that the conditions then were the same as before the war. Under existing conditions, the cost is 5s., thus showing 8d. per ton in favor of the motor, which means that if all the dry-ash refuse were removed by motors a saving of over £1,000 per annum would be effected, and this in a town not considered best adapted to motor traction for this class of work. These are the results obtained by the No. 1 motor; the figures for the No. 2, which has been at work daily since March 13th, are identical.

Mr. Priestley, cleansing superintendent, Sheffield, whose experience of electric motors in the collection of house refuse is greater than that of any other superintendent, recently presented a report to his committee, containing the following figures:

No. 1 Vehicle.—Day Work Costs for 22 Weeks.
Refuse collected, 858 tons, 6 cwt., 1 qr.

| | £ | s. | d. |
|---|---|---|---|
| Wages | 154 | 15 | 8 |
| Vehicle costs | 40 | 7 | 1 |
| Electricity, 3,269 units | 13 | 12 | 5 |
| Tires, 2,168 miles | 9 | 0 | 8 |
| | £217 | 15 | 10 |

Cost per ton, 5s. 0.8d.

Cost of one month's work on same districts with horse labor:
Refuse collected, 167 tons, 19 cwt., 2 qr.

| | £ | s. | d. |
|---|---|---|---|
| Cost | 59 | 1 | 9 |

Cost per ton, 7s. 0.4d.

No. 1 Vehicle.—Night Work Costs for Tyenty-one Weeks.
Refuse removed, 1,142 tons, 18 cwt., 1 qr.

| | £ | s. | d. |
|---|---|---|---|
| Wages | 72 | 3 | 8 |
| Vehicle costs | 38 | 10 | 5 |
| Electricity, 2,927 units | 12 | 3 | 11 |
| Tires, 1,880 miles | 7 | 16 | 8 |
| | £130 | 14 | 8 |

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* £ = $1.86; s. = 24 ct.; d. = 2 ct.

Cost per ton, 2s. 3.4d.
Cost of three months' work on same districts with horse labor.
Refuse removed, 473 tons, 11 cwt., 2 qr.

| | £ | s. | d. |
|---|---|---|---|
| Cost | 77 | 10 | 3 |

Cost per ton, 3s. 3.2d.
No. 2 Vehicle.—Day Work Costs for Six Weeks.
Refuse collected, 311 tons, 4 cwt., 3 qr.

| | £ | s. | d. |
|---|---|---|---|
| Wages | 47 | 10 | 5 |
| Vehicle costs | 10 | 19 | 3 |
| Electricity, 670 units | 2 | 15 | 10 |
| Tires, 417 miles | 1 | 14 | 9 |
| | £63 | 0 | 3 |

Cost per ton, 4s. 0.1d.
Cost of one month's work on same district with horse labor:
Refuse collected, 204 tons.

| | £ | s. | d. |
|---|---|---|---|
| Cost | 38 | 16 | 0 |

Cost per ton, 's. 9.6d.
No. 2 Vehicle.—Night Work Costs for Six Weeks.
Refuse removed, 406 tons, 13 cwt., 2 qr.

| | £ | s. | d. |
|---|---|---|---|
| Wages | 21 | 18 | 0 |
| Vehicle costs | 10 | 19 | 3 |
| Electricity, 758 units | 3 | 3 | 2 |
| Tires, 459 miles | 1 | 18 | 3 |
| | £37 | 18 | 8 |

Cost per ton, 1s. 10.3d.
Cost of one month's work on same district with horse labor:
Refuse removed, 440 tons, 8 cwts.

| | £ | s. | d. |
|---|---|---|---|
| Cost | 55 | 10 | 2 |

Cost per ton, 2s. 6.2d.

Mr. Jackson, cleansing superintendent, Birmingham, who has been working an "Orwell" dust van since May 29th, reports that it is equal to 2.5 horses.

## PROPOSED $1,500,000 HIGHWAY SYSTEM FOR STANISLAUS COUNTY, CAL.

The Supervisors of Stanislaus County, California, contemplate a $1,500,000 bond issue for the construction of a system of highways. The plan calls for the surfacing of approximately 126.1 miles of road, with a 1:2½:5 concrete base of a minimum thickness of 4 in., and a wearing surface to consist of a mixture of asphaltic oil and screenings. The oil is to be applied at the rate of approximately ½ gal. to the square yard of surface and enough screenings added to take up all surplus oil.

The 16-ft. concrete roads are to have a width out to out of earth shoulders of 24 ft., the 12-ft. concrete roads are to have a width out to out of earth shoulders of 20 ft. with a suitable gutter on each side for drainage.

In a report to the County Supervisors E. H. Annear, County Surveyor, Modesto, Cal., estimates the cost of the work at $1,482,850. Table I, from his report, gives some details of the proposed improvements.

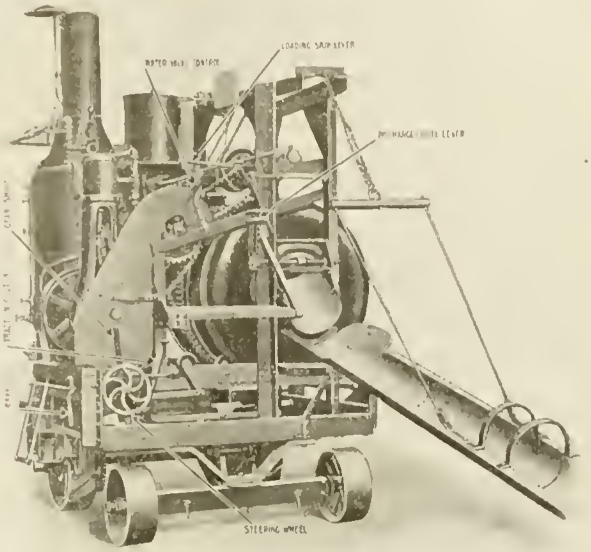
TABLE I.—ESTIMATED COSTS AND TYPES OF CONSTRUCTION FOR PROPOSED HIGHWAY SYSTEM OF STANISLAUS COUNTY, CALIFORNIA.

| | | | Cost of | | | | Material for cement-concrete base. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Name of road. | Width, feet. | Length, miles. | Grading, cement-concrete base and wearing surface. | Culverts and bridges. | Engineering and inspection. | Total cost. | Barrels cement. | Tons sand. | Tons rock. | Kind of wearing surface. |
| Hickman-Thalheim | 12, 16 & 20 | 17.054 | $ 171,688 | $ 7,850 | $ 9.064 | $ 188,602 | 19,780 | 9,494 | 19,780 | Oil screenings and bitucrete. |
| Waterford | 12 & 16 | 20 190 | 219,472 | 3,190 | 11,266 | 233,928 | 23,777 | 11,413 | 23,777 | Oil screenings and bitucrete. |
| Hughson | 16 | 6.200 | 67,051 | 2,650 | 3,519 | 73,220 | 8,060 | 3,869 | 8,060 | Bitucrete. |
| Keyes | 16 | 3.516 | 36,893 | 2,430 | 1,984 | 41,307 | 4,563 | 2,190 | 4,563 | Oil screenings. |
| Hughson-Turlock | 12 | 6.600 | 58,603 | 4,410 | 3,178 | 66,191 | 6.435 | 3,089 | 6,435 | Oil screenings. |
| Crows Landing | 12 & 16 | 17.900 | 196,533 | 10,530 | 10.473 | 217,536 | 20,177 | 9,685 | 20,177 | Oil screenings. |
| Grayson | 12 | 4.005 | 41,577 | 1,640 | 2,181 | 45,398 | 3,905 | 1,874 | 3,905 | Oil screenings. |
| Glendora | 12 & 16 | 7.400 | 81,917 | 4,470 | 4,359 | 90,746 | 8,320 | 3,994 | 8,320 | Oil screenings and bitucrete. |
| Denair | 16 | 3.750 | 40,221 | 1,870 | 2,124 | 44,215 | 4,875 | 2,340 | 4,875 | Bitucrete. |
| Irwin City | 16 | 2.243 | 24,513 | 2,200 | 1,347 | 28,060 | 2,916 | 1,400 | 2,916 | Bitucrete. |
| Newman-Westley | 16 | 19.430 | 227,399 | 4,150 | 11,696 | 243,245 | 25,259 | 12,124 | 25,259 | Bitucrete. |
| Paradise | 16 | 5.400 | 64,575 | 280 | 3,273 | 68,128 | 7,020 | 3,370 | 7,020 | Bitucrete. |
| Maze | 16 | 4.040 | 45,123 | 3,140 | 2,434 | 50,697 | 5,252 | 2,521 | 5,252 | Bitucrete. |
| Carmichael | 12 | 3.700 | 32,555 | 1,640 | 1,725 | 35,920 | 3,608 | 1,732 | 3.608 | Oil screenings. |
| Peckwith | 12 | 4.400 | 44,230 | 3,070 | 2,386 | 49,686 | 4.290 | 2,059 | 4,290 | Oil screenings. |
| Oakdale | 12 | 0.322 | 5,685 | ..... | 286 | 5,971 | 309 | 148 | 309 | Oil screenings. |
| Grand totals | .. | 126.144 | $1,358,035 | $53,520 | $71,295 | $1,482,850 | 148,546 | 71,302 | 148,546 | |

## THE CINCINNATUS TRACTION PAVER.

One of the latest designs of traction pavers is shown in the accompanying illustration. It is the Ideal Cincinnatus Mixer, manufactured by the Ideal Concrete Machinery Co., Cincinnati, O. The mixer shown is equipped with a 6 H.P. steam engine and an 8 H.P. boiler. The view shows the discharge end of the mixer and the 15-ft. discharging chute, which can be swung 180° and is made in three hinged sections, which enables the concrete to be distributed evenly and quickly.

This particular view of the mixer shows the arrangement of the controlling levers which makes Cincinnatus paving mixers so convenient to operate. All the levers controlling the loading skip, the water control and the discharge chute are operated from a platform on the discharge end of the mixer so that the operator has everything under his control and can keep the whole gang going at top speed. All the levers controlling the traction gears are conveniently placed where the operator can walk right along beside the mixer and see that it is running on the planks. These equipments are made in 5, 7 and 10-ft. sizes and are also supplied with gasoline engines instead of steam engines at reasonable prices if desired.



Ideal Cincinnatus Traction Paver.

## ROAD AND BRIDGE EXPENDITURES IN UNITED STATES.

Rapid increase in total expenditures for roads and bridges, growth of building and maintenance activities under State supervision, and a sharp decrease in the proportion of contributions in the form of statute labor mark the development of highway work in the United States during the past 12 years. These facts are brought out by statistics for the calendar year 1915 recently compiled by the Office of Public Roads and Rural Engineering of the U. S. Department of Agriculture.

The total length of public roads in the United States outside the limits of incorporated towns and cities was about 2,452,000 miles on Jan. 1, 1916. Of this, about 277,000 miles, or 11.3 per cent, were improved with some form of surfacing. The mileage of surfaced roads has been increasing at the rate of about 16,000 miles a year, and in 1915 approximately one-half of this increase was made under the supervision of State highway departments. In addition these departments supervised the maintenance of nearly 52,000 miles of main and trunk line roads.

The increase in expenditures for road and bridge work in the United States has been from approximately $80,000,000 per year in 1904 to about $282,000,000 in 1915, an increase of more than 250 per cent. The expenditure of State funds during this same period increased from about $2,550,000 to more than $53,000,000. In addition, more than $27,000,000 of local funds was spent under State supervision in 1915, bringing the total road and bridge expenditures managed by the States to $80,514,699. This amount is greater than the total expenditures for roads and bridges from all sources in 1904.

The growth in importance of the State highway departments has been rapid. The first of these agencies was created in 1891 in New Jersey and now some form of highway department exists in every State except Indiana, South Carolina, and Texas. Since their inception these departments had expended to Jan. 1, 1916, an aggregate of $265,350,825 in State funds for road and bridge construction, maintenance, and administration. They had constructed over 50,000 miles of roads in co-operation with the States. More than 40,000 miles of these roads were surfaced.

The falling off in the value of road work performed by statute and convict labor was from $20,000,000 in 1904, when the total road expenditures were $80,000,000, to about $15,000,000 in 1915, when the total expenditures had grown to $282,000,000. This was a reduction from 25 per cent of the total in the former year to less than 5½ per cent of the total in 1915.

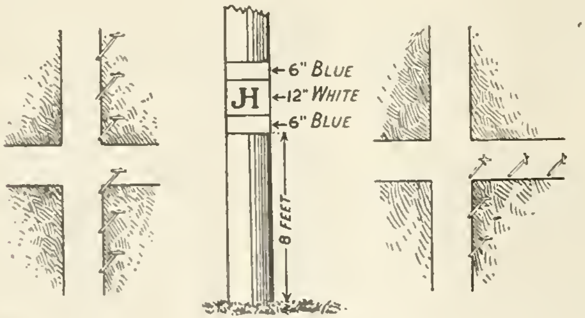
An increase in the use of better and more expensive types of roads also is shown by the recently compiled statistics. This development has been due, in large part, to the great increase in automobile traffic. It is estimated that there are now approximately 2,500,000 automobiles in use on the roads of the country, or 1 car for every mile of road. This present motor traffic is in excess of traffic of all sorts 12 years ago.

The cash road and bridge expenditures of the United States averaged only $28 per mile of rural roads in 1904. In 1915 this average had grown to $109 per mile. New Jersey led all other States both in 1904 and in 1915 with $221 and $475 per mile, respectively. Nevada made the least expenditure in both years—$3.72 per mile in 1904 and $17 per mile in 1915.

## ROAD SIGNS FOR JEFFERSON HIGHWAY.

An interesting system of pole markings for direction signs will be employed on the Jefferson Highway. At any turn or divergence there will be five pole marks as follows:

Five or six poles at each cross or intersecting road will be painted, as shown by diagram, indicating the route of the trail. The strip will commence 8 ft. from the ground with a 6-in. band of blue; above this there will be a 12-in. band of white; above this another 6-in. band of blue. The monogram initials J-H will be in black on the white facing of the trail. Two coats of paint will be applied, the blue being the shade of the blue in the national flag. Metal signs will be furnished by the association to the extent of one sign to each mile of highway in the county. These signs are to be placed by the several counties on substantial posts at each cross road or diverging road as follows:



Mark three poles each side of intersection on straight way.

Diagram showing correct pole marking.

Mark one pole at corner and two poles each side of turns at intersections.

Pole Marking System for Jefferson Highway.

First: If the highway is straight ahead, the sign must be placed parallel with the highway near the fence or property line.

Second: If the highway turns to the right, the sign is to be placed at an angle of 45° across the left-hand corner.

Third: If the highway turns to the left, the sign is to be placed at an angle of 45° across the right-hand corner. The bottom of sign is to be 6 ft. from the ground.

## PERSONALS.

Arthur M. Porter has been appointed city engineer of Redwood City, Calif.

R. C. Watson has resigned from the engineering department of the St. Joseph Lead Co. to join the engineering department of the Donk Bros. Coal and Coke Co., St. Louis, Mo.

F. H. Tillinghast and W. Parker Ireland have formed the engineering firm of Tillinghast & Ireland, and will specialize in irrigation, drainage, hydraulic and sanitary engineering. Offices will be maintained in the Forum building, Sacramento, Cal., and the Nixon building, Reno, Nev.

R. P. Boyd, for several years assistant state highway engineer of Alabama, has resigned that position to take charge of a $500,000 road improvement in Ouachita Parish, Louisiana. J. P. Converse, for a number of years resident engineer of the Alabama State Highway Commission, succeeds Mr. Boyd as assistant state highway engineer.

H. E. Stevens, engineer of bridges of the Northern Pacific Ry., has been appointed chief engineer to succeed W. L. Darling, whose resignation became effective Oct. 1. Mr. Darling has been chief engineer of the Northern Pacific since 1905. He also was chief engineer from 1901 to 1903, resigning in the latter year to become chief engineer of the Chicago, Rock Island & Pacific R. R. He was with this latter system until 1905, when he returned to the Northern Pacific.

The Western Society of Engineers is represented in Company A, Illinois Engineers, now in Camp Cecil A. Lyon at Fort Sam Hauston, San Antonio, Texas, by a number of officers and privates, as shown in the following list: Horace S. Baker, first lieutenant; C. C. Saner, first sergeant; D. A. Tomlinson, supply sergeant; James A. Cook, corporal; H. F. Beyer, private; M. D. Kolyn, private; Max Kushlan, private; N. M. Stineman, private. Several other members, who were originally with the company, were excused at Springfield for legitimate reasons.

The second annual conference of the Committee on Engineering Co-operation, held in Chicago last April, adopted a resolution providing for a sub-committee of four men selected by the chairman, to act with him in the preparation of a plan to be submitted for consideration at a third conference called for the purpose. Conforming to the instructions in this resolution, F. H. Newell, chairman of the committee, has named Hunter McDonald, Isham Randolph, M. L. Cooke and C. E. Drayer as members of a sub-committee on plan. A first draft of a plan has been made and is in the hands of the sub-committee, which will probably meet during the next month for further consideration of it.

## INDUSTRIAL NOTES.

The Austin-Western Road Machinery Co., Chicago, Ill., recently made a shipment of forty Austin sprinkling wagons for use with the U. S. Army on the Mexican border. The machines are the Austin standard 600-gal. platform spring type with steel tanks.

The John Kline Brick Co., Wickliffe, O., is the newest and the 34th member of the Dunn Wire-Cut Lug Brick Co.'s family of licensees. This is a well-constructed and well-managed plant with a daily capacity of 40,000. Mr. J. C. Kline is president of the company.

Robert C. Clifford, who has for the past four years been district sales manager for the United States Cast Iron Pipe & Foundry Co., in charge of their St. Louis and Kansas City offices, is now associated with the Walter A. Zelnicker Supply Co., in St. Louis, in charge of their rail department.

On Sept. 1, 1916, Lewis Institute, Chicago, and the Portland Cement Association, 111 West Washington street, Chicago, entered into an agreement whereby they will hereafter jointly operate the Structural Materials Research Laboratory at Lewis Institute. This laboratory has, during the past two years, attained merited distinction for the work which it has done.

Among the contracts recently awarded the Raymond Concrete Pile Co. of New York and Chicago are the following: Concrete piles in the foundation of an extension to Wire Mill No. 2 of John A. Roebling's Sons Co., Roebling, N. J. Frank W. Bunn, engineer.—Concrete piles and footings for the foundation of building for the Adriance Machine Works, Inc., Verona and Richard streets, Brooklyn, N. Y. R. I. Dodge, architect.—Approximately 4,500 Raymond concrete piles in the foundation of a plant at Indiana Harbor, Ind., for the Mark Mfg. Co.—Concrete pile foundation for the Clay School, Hegewisch, Ill.—The Packard Motor Car Co. are to have Raymond concrete piles in the foundation of their new building at Long Island City. Albert Kahn, architect.—Concrete piles in the track scale and chipping building of the Youngstown Sheet & Tube Co., Youngstown, O.—Concrete piles in the addition to the Boys' School, Eleventh street and Second avenue, New York City. C. Weiskopf, architect.

The Tenth Chicago Cement Show will be held in the Coliseum and balcony, Wednesday, Feb. 7, to Thursday, Feb. 15, 1917, inclusive. The concentration of exhibits in the Coliseum, Balcony and Annex will enable visitors to inspect them conveniently. Machines and products will be closer together, thus facilitating comparison and enabling buyers to make purchases more expeditiously. However, as less space will be available for the next show than for the last show, each exhibitor will be asked to apply for as little space as can accommodate his exhibit and in this way it is hoped to make the number of disappointed applicants as small as possible. There will probably be a joint exhibit of cement companies similar to the one at the last show. During the eight-day period Chicago will be the center of activity in the building material industry. The National Builders' Supply Association will hold its annual convention at the Hotel Sherman Feb. 11 and 12, and the Illinois Lumber & Builders' Supply Dealers' Association at the same hotel Feb. 13 and 14. While the dates have not been definitely set, it is possible that the American Pipe and Tile Association will be in session during the cement show. It is also likely that the American Concrete Institute will meet at the same time. Besides these organizations, it is possible that the American Association of Engineers and other similar associations will convene in Chicago during the show.

Water Works and Hydraulics Monthly Issue
of

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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## COMPETING WATER WORKS SOCIETIES AND THE RESULTING LOSS OF EFFICIENCY.

The New England Water Works Association and the American Water Works Association have more than 1,000 members each. Joined together they would speedily reach a membership of 2,500 to 3,000. This alone would serve to attract more members with great rapidity, for there is unquestionably a stronger mental gravitation toward a large organization than toward a small one.

Each of these two technical societies has been in existence more than 34 years, yet thus far the growth of neither one has been satisfactory. Who can doubt that had their efforts been combined from the beginnng much greater results would have been attained?

When the question is bluntly put to members of either society as to the reasons why there is not a single water works association instead of two, seldom is reply made that two such societies are to be preferred to one. Instead, some such statement as this is made: "So long as old jealousies exist—and they will exist until the death of many of the older members—it is futile to talk consolidation." But is it? Neither of these societies is being exploited for personal profit—professional or otherwise—we take it, but both exist as organizations for "the advancement of knowledge." The first article of the constitution of The New England Water Works Association reads:

> Its objects shall be the advancement of knowledge relating to water works and water supply, and the encouragement of social intercourse among water works men.

The corresponding article of The American Water Works Association reads:

> The object of this Association shall be the advancement of knowledge of the design, construction, operation and management of water works, and the encouragement, by social intercourse among its members, of a friendly exchange of information and experience.

Both articles are admirable in spirit and almost identical in expression. There is, then, not the slightest divergence in the aims of these two societies. Why, therefore, the continued dis-unity of effort toward the common goal? Surely the "encouragement of social intercourse among water works men" will be greatly fostered if more water works men convene in one society at one time. Why the two societies, the two annual conventions, the two sets of officers, the two journals? Jealousy? If so, and we fear there is no other cause, is it not time that the great majority of members of these two societies insist upon a subordination of the jealousy of a comparatively few members to the welfare of the vastly larger number who are not jealous.

The water works superintendent and engineer have long been the plaything of politics in many an American city. To whom shall we look to remedy this condition if not to a national organization of water works men? The power of such a body of men is proportional to their numbers, and their enthusiasm, but enthusiasm itself is a function of the number of men engaged in a common object. If the water works of every city in America were represented in one water works association, and if that association earnestly undertook to drive politics out of water works management, there is not the slightest doubt as to the success of the endeavor. A vast public good would be thus secured, and, incidentally, the entire water works fraternity would greatly benefit.

## CHICAGO'S WATER WASTE, AND THE OPPORTUNITY FOR CHICAGO ENGINEERS.

Milwaukee consumes about 100 gal. of water per capita per day. Chicago consumes 236 gal. per capita per day. Every year the engineer's report to the Chicago Commissioner of Public Works urges the metering of the water supply. We quote from the last annual report:

> Of the total amount of water pumped a conservative estimate places the waste through leaky fixtures, wilful wastage and underground leaks at 50 per cent.

Were this waste eliminated 4 of the 9 major pumping stations would be rendered unnecessary, reducing the operating expense by $700,000 a year! To quote again:

> The generally recognized remedy for wasting of water is the installation of meters. I submit that any merchant would be considered peculiar if he should offer to supply sugar, butter or lard to a family for so much a month regardless of the quantity used. The electric light and gas companies do not furnish their commodities for a flat rate irrespective of the quantities used. The city, however, in supplying water adheres generally to this policy, and, although there are arguments advanced to continue this method, the arguments are extremely weak.

Shouldn't the Engineer's Club of Chicago associate itself with business and professional organizations in Chicago in a grand effort to stop this grand waste? Proper publicity will lead to meterage of Chicago's water supply. What body of men is more competent to furnish material for a publicity campaign of this character than are the engineers of Chicago? We engineers are talking a great deal nowadays, about our public obligations. Here is a chance to turn talk into action, an action that will save an annual expense which capitalized at 5 per cent is $14,000,000.

## THE WATERWORKS AND HYDRAULIC MONTHLY ISSUE OF "ENGINEERING AND CONTRACTING."

Beginning last July "Engineering and Contracting" took a somewhat radical step in engineering journalism when it grouped together all its articles relating to the different branches of civil engineering, and published them in four "monthly issues." Our third advertising page lists these four "monthly issues," but we wish here to say a word about our Waterworks and Hydraulic Monthly Issue, of which this one is the fourth.

In a sense each of these four waterworks issues (July to October) speaks for itself, yet it seems advisable also to offer an editorial word about the new plan and its reception. During the past ten years Engineering and Contracting has regularly published data on waterworks, sewers and hydraulics every week. In the aggregate for each year this information has been great, but the amount lacked impressiveness because it was only a fractional part of the reading matter in each of the 52 issues; furthermore, it was not readily available for reference, because it was so widely scattered. By bringing all the articles on hydraulic subjects together in one issue—published the second Wednesday of each month—we are able to make prospective waterworks men recognize at a glance the importance of this journal, and we also make it easy for anyone to file away for reference all the articles on hydraulic subjects.

The result of these changes, coupled with the fact that a subscription for our Waterworks and Hydraulic Monthly issues is only $1 a year, have served to add a far greater number of new subscribers in the waterworks field during the past 90 days than during any similar period of our history. In short, our faith in this method of publishing a civil engineering journal has been justified by the results thus far secured.

### WHY HAVE TWO WATERWORKS "SHOWS"?

The recent convention of the New England Waterworks Association again serves to indicate the economic waste of having two annual exhibitions of waterworks machinery and supplies. If the comments made by several exhibitors indicate what their action will be next year, it is evident that there will be a decided decrease in the number of exhibitors at the New England convention. Similar comment year before last was made by exhibitors at the two road conventions, and a marked falling off in the number of exhibits occurred last year at one of those "shows." This is inevitable, for it costs no small sum to prepare, transport and stage these exhibits of machinery and appliances. Exhibitors will not indefinitely continue a doubling of such expense.

A society of an engineering nature may reply that its existence will not be jeopardized by the elimination of the exhibition or "show feature," and that is true, but the usefulness of the society will certainly be curtailed by any act that tends to remove its members from sources of information such as manufacturers possess.

Engineers have learned that a large "show" of manufactured products is often the most interesting part of a convention, and frequently the part that yields the most usable information. Let the effort be to have but one waterworks exhibit next year, and that one the best in the history of hydraulics.

### IRRIGATION OF GARDENS IN CITIES.

The pupils in the public schools of several cities are being encouraged by their teachers to plant vegetable gardens in their back yards. In some instances school grounds are used for garden purposes and the pupils are taught scientific gardening. This is a move that should be encouraged by water works managers in all cities. But to give an encouragement that will really encourage gardening of this sort, it will be necessary to supply water for irrigation, for even in the so-called humid areas of America the full efficiency of a garden cannot be secured without the use of irrigation.

Objection to the use of city water for such a purpose is often made on the ground that the water supply is already limited. This may be true, but the scarcity of water is nearly always attributable to wastage of one sort or another. The solution of the wastage problem and the solution of the irrigation problem go hand in hand. The answer is meters. Meters will greatly reduce waste, and, with a properly graduated scale of rates, the water saved from waste will be used to increase the production of "garden truck."

Let waterworks men once come to look upon water as a commodity, like gas, to be marketed at prices that will attract new customers, and we shall see a great rejuvenation of the whole waterworks industry.

### "THERE IS MORE CONFIDENCE IN THE FUTURE."—NATIONAL CITY BANK OF NEW YORK.

In its October review of economic conditions and finance, The National City Bank of New York says:

> There is more confidence in the future than has been felt at any time in the last two years. This does not mean that there are no apprehensions of an industrial slump after the war, but that with the profits of the last year applied to indebtedness or added to resources, the position of the industries is inherently stronger. Moreover, there is a feeling that business is accumulating which will come forward when war orders are out of the way. In nearly all lines there is difficulty in getting orders filled. Foreign trade in ordinary merchandise in all parts of the world, is growing, because there is no other place to get the goods and this fact will prevent any accumulation of stocks until some time after the war.

The continued flow of gold from Europe, due to our enormous exports, is positvely amazing. Customs returns show that for the first eight months of 1916 more than $410,000,000 in gold has been imported. At this rate the year of 1916 will witness an increase of $615,000,000 in the gold supply of this country.

Not only is this gold seeking investment, but upon every dollar of it there is built three additional dollars of available credits. The sum total of gold and credits added in one year is staggering.

To engineers and contractors it is certainly refreshing news, after a somewhat long period of aridity, to know that all financially sound engineering projects, private or public, will find an eager money market. Contrasting the financial situation now with what it was two years ago gives nearly everyone in America cause for great satisfaction.

### EDITORIAL COMMENTS.

There are about 120 engineering schools in America. This number seems large until expressed as a ratio to the population or 1 engineering school to 800,000 people. The development of engineering schools is a long way from being overdone. In fact it has hardly begun, for engineering science should enter every industrial occupation. Let the public learn the wide utility of engineering knowledge if we would increase the demand for engineers.

Mr. John A. Ferguson, Secretary-Engineer, Building Code Commission, City of Pittsburgh, in discussing Dr. Waddell's paper recently read before The Engineers' Society of Western Pennsylvania, said:

> That engineer who can co-ordinate and arrange all the work, being done, for the advancement of the business enterprise, so plan and scheme it that it will be done well enough to bring about the end desired in the speediest and least expensive manner is called the Executive Engineer, is paid the most for his time, is given the greatest responsibilities, not even second to the financier who must provide the money. Consequently when those who provide the money have been clearly shown that such is the case, and how much they depend upon men of this character, they will pay the proper amount of recompense to the man who can force them to see the necessity thereof by the simple presentation of all related subjects briefly, accurately and in a business manner, and they will not need much convincing when the balance sheets for cost show what has been or can be done for them.
>
> As it will thus be seen, engineers must get to be business men if they expect to attain eminence in their profession, and they must present to business and financial men clearly, succinctly and briefly the advantages to be obtained by their employment and the employment of the highest and best professional men commensurate with the task to be performed and the actual economy of so doing. Common observation will teach us that nobody is going to be looked upon as successful in his undertakings unless he pays his way, be his interest what it may.

"It should be considered a deep disgrace for any [engineering] student to sell a textbook after he has finished the course of instruction in which it was employed. * * * No books can quite take the place of those which one uses at college, even if much better treatises are later available."—J. A. L. Waddell. This is good advice, and even better is Dr. Waddell's statement that "Much of an engineer's success depends upon the size and character of the technical library which he accumulates."

Anent the increasing use of liquid chlorine we quote the following from the last annual report of Mr. Edgar M. Hoopes, Jr., Chief Engineer of the Water Department of Wilmington, Del.

"Were it not for the use and efficiency of Liquid Chlorine as a sterilizing agent, the sanitary quality of the water supply could not be maintained."

At the end of last year 94 per cent of the 21,306 services in Wilmington, Del., were metered. As a result 641,000,000 fewer gallons of water were pumped during the year than during the previous year. The total decrease in domestic consumption of water was nearly 1,000,000 gal. a day. The total average daily consumption has been reduced to 102 gal. per capital or 20.8 per cent less than for the previous year, and the end is not yet.

## CHANGE IN AREA OF CROTON WATER SHED.

To the Editor: Attached hereto is a detailed statement in reference to a change in the adopted area of the Croton water shed above the new Croton dam, from 360.44 square miles to 375 square miles.

This matter is considered of sufficient importance to be brought to the attention of the engineers interested in water supply and other hydraulic work, and I trust that you will give it suitable mention in your publication, condensing the department statement as far as may be considered advisable.

Very truly yours, Wm. W. Brush,
Acting Chief Engineer, Bureau of Water Supply, New York City.

Sept. 14, 1916.

The statement in condensed form follows:

The area of the Croton watershed lying above the old Croton dam has been generally reported as 338.8 square miles for the past fifty or more years. To this area was added 21.6 square miles as tributary watershed between the old Croton dam and the new Croton dam, making the generally reported area of the Croton watershed lying above the new Croton dam as 360 square miles. In 1916 the engineers of the Bureau of Water Supply were convinced that these areas were incorrect, and as a result of investigations made during the past six years adopted 375 square miles as representing the correct area of the Croton watershed lying above the new Croton dam.

The area of 360 square miles, previously used, has its sole foundation on the printed area which appears on the lithograph copy of the map of 1858. The accuracy of this statement is disproved by (a) the printed report of the Croton Aqueduct Department for 1858; (b) by the planimetered and computed area of the watershed, shown on this lithograph of the 1858 map; (c) by errors found in the table of subdivisions given on the lithograph, the maximum error found being 10 square miles in an area given as 75 square miles, which should have been 85 square miles.

The newly adopted area of 375 square miles is supported by the following: (a) By the area of the watershed determined from the lithograph of the 1858 map, using the graphic scale appearing on the lithograph and the outline of the watershed as defined thereon. (b) By the statement appearing in the annual report of the Croton Aqueduct Department for 1858. (c) By the areas determined from the Worthen map by different methods which vary by less than one square mile.

The Department of Water Supply, Gas and Electricity has changed the area of the watershed because it believes that an error in the watershed area of the Croton River should be corrected in justice to the engineering profession, which has in the past and probably will in the future make frequent use of the record of rainfall and runoff of the Croton watershed, which constitutes one of the most valuable and most widely consulted watershed records in the United States.

## OPERATING COST OF CERTAIN RAPID SAND FILTER PLANTS.

In their recently issued report on a new water supply for the city of Sacramento, Cal., the engineers, Messrs. Hyde, Wilhelm and Miller, give some interesting figures on the cost of operation of certain rapid sand filter plants. The data, of course, are approximate and somewhat indefinite since the various plants represented are operating in waters of widely different character and composition, and at various percentages of their nominal capacity. In connection with the data figures are given for proposed plant for Sacramento. The table follows; the costs, except as noted, not including any fixed charges nor the cost of pumping water to or from the plant:

| Name of place. | Period of record. | Average volume of water treated, mill. gal. per day. | Cost of operation per million gal. treated. |
|---|---|---|---|
| Cincinnati, O. | 1913 | 50 | $ 3.44† |
| Columbus, O. | 1914 | 18 | 17.00* |
| Evanston, Ill. | Sept. 1-Dec. 31, 1914 | 7.8 | 3.35 |
| Grand Rapids, Mich. | Apr. 1, '13-Mar. 31, '14 | 14.3 | 10.96*‡ |
| Harrisburg, Pa. | 1910-1914 | 8.6 | 3.40§ |
| Little Falls, N. J. | 1912 | 30 | 3.20 |
| Louisville, Ky. | 1912 | 25 | 3.50 |
| New Orleans, La. | 1913 | 16 | 6.30* |
| Straight averages |  | 21.2 | $ 6.64 |
| Weighted average |  | .... | 5.85 |
| Estimated for Sacramento |  | 20.00 | $ 4.90¶ |
| Estimated for Sacramento |  | 30.00 | 1.60¶ |

*Including cost of softening.
†Operating the plant = $1.77; chemicals = $1.67.
‡Wages = $3.17; chemicals = $4.82; current = $2.06; supplies and repairs = $0.91.
§Low-lift pumping included in these figures.
¶These figures do not include the cost of low-lift pumping.

## METER INSTALLATION AT WILMINGTON, DEL.

The project of installing meters on all properties in the city of Wilmington, Del., was started under the authority of the Board of Water Commissioners on May 8, 1914. The total number of installations from that date to July 1, 1915, was 9,180. At the later date there were 21,300 services in use of which 19,883 or 93.3 per cent were metered, and the work of metering every service in the city was being pushed rapidly to completion. The following description of the methods employed in making these installations is taken from the last annual report of the Board of Water Commissioners.

### Organization.

The force engaged on the work varied from time to time, especially as regards laborers, but conformed on the average to the following schedule:

| Grade. | Number employed. | Rate per hr. ct. |
|---|---|---|
| Plumber | 1 | 37½ |
| Pipe fitter | 7 | 33⅓ |
| Helpers | 8 | 25 |
| Pavers | 2 | 37½ |
| Drivers | 2 | 25 |
| Laborers | 10 to 20 | 20 |
| Cart and horse | 1 | 25 |
| Auto truck | 1 | 50 |
| Street shop wagon | 1 | .. |

Under the direct supervision of the Engineering Department, the plumber acted as the foreman of the working force. All employes reported each morning to the street shop wagon (see Figs. 1 and 2), which was located at the point of starting the day's work. The necessary equipment of tools and supplies was contained in this wagon; depletions of stock were filled daily from the main store room, by use of the auto truck.

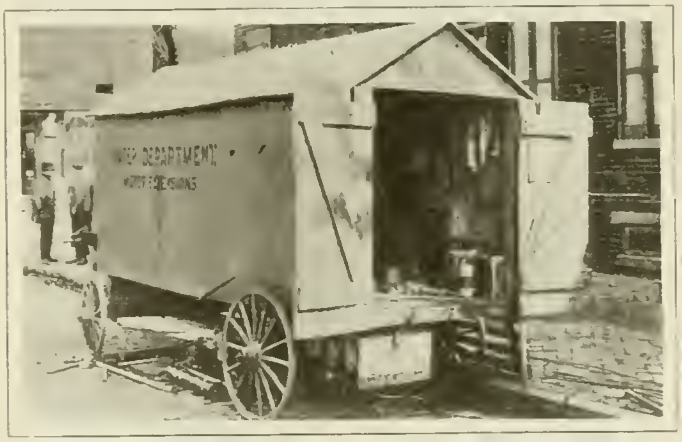


Fig. 1—Pipe and Meter Shop.

### Plan of Operation.

Slips were prepared each day at the main office, containing the street number of every house in the district in which the force was working, and a notation as to whether or not the house was already metered. These slips were distributed to the fitters at the start of the day's work, and were turned into the foreman as the meters were installed. They were then approved by him, and returned to the main office for the purpose of permanent entry in the Department's books. In addition each fitter was required to enter on a printed form a report of each meter installed with its location, or notation of any service complications or other reason preventing its installation.

When such complications existed, the fitter's report was returned to the Engineering Department, and the property owner notified by letter to remedy the condition within 30 days. At the expiration of this time an inspection was made, and if the situation had been corrected, the meter was ordered installed. For this purpose two men were employed who worked independent of the main force, in order that the progress of the latter might not be held up. In cases where the property owner failed to comply with the requirements, the contract for a supply of water to such property was canceled. In this connection it is important to note that service complication existing between the main and curb line were taken care of by this department, while those existing between the curb and building line were corrected by the property owner. It is also interesting to note that before any meter was installed, and prior to making an inspection for such purpose, the tenant of each house was supplied with literature explaining the nature of the work, and the benefits resulting therefrom.

From May 8th to June 30, 1914, 1,233 meters were placed, of which 239 were curb and 994 cellar installations. From June 30, 1914, to July 1, 1915, the number of installations was 9, 180 of which 4,055 were curb and 5,125 cellar settings. Throughout the winter the work was continued without interruption, the working force being confined to cellar installations during periods of bad weather. The department was confronted with the question of deciding on "curb" or "cellar" settings, when plans for metering the entire city were under contemplation. After carefully considering the advantages of curb installations, and the additional expense necessitated thereby, the problem was solved by adopting the following policy:

Fig. 2—Interior of Pipe and Meter Shop.

1. Meters to be set at curb on all new properties.
2. Meters to be set at curb on properties without cellars; except where the probable life and nature of the building did not warrant the expense of a curb setting.
3. Meters to be set at curb when requested by property owner.
4. Meters to be set at curb where danger of freezing existed, if installed in cellar or where cellar did not permit of convenient location from meter reader's standpoint.
5. All meters not covered by above stipulations to be located in cellars.

### Contract for Meters.

The contract for meters under this project was awarded to the Hersey Manufacturing Co. of Boston, Mass., in accordance with the following synopsis of specifications:

**Guarantee.**—All meters were guaranteed against defects in material and workmanship for a period of two years commencing with the date of service.

**Exceptions.**—Breakage from external causes; damage by hot water or freezing, or when the duty of any meter equals or exceeds the following amounts:

| | |
|---|---|
| ⅝-in. | 500,000 cu. ft. |
| ¾-in. | 900,000 cu. ft. |

**Accuracy.**—No meter was accepted which registered less than 98 and more than 100 per cent of the actual amount of water passed through the meter as determined by weight at full opening of the outlet. In addition the accuracy of each meter was required to be from 98 to 100 per cent when the quantities of water passed on each of the different streams opposite its size was as shown on the following table:

| Diameter of orifice | ⅝-in. Cu. ft. | ¾-in. Cu. ft. |
|---|---|---|
| 1/16 | 1 | 1 |
| 1/4 | 2 | 2 |
| 1/2 | 5 | .. |
| 3/4 | .. | 5 |

**Sensitiveness.**—All meters were required to register from 90 to 100 per cent of the water passed as determined by weight at the following rates:

| | |
|---|---|
| ⅝-in. | 2 cu. ft. per hour |
| ¾-in. | 3 cu. ft. per hour |

All tests were conducted under a working pressure of 40 lbs. The department was also protected from infringement of patents, or the payment of royalties for the use of any patents connected with the particular meter, and in addition was supplied with a guaranteed price list at which each of all the different parts of each size of meter could be purchased when required for repairs.

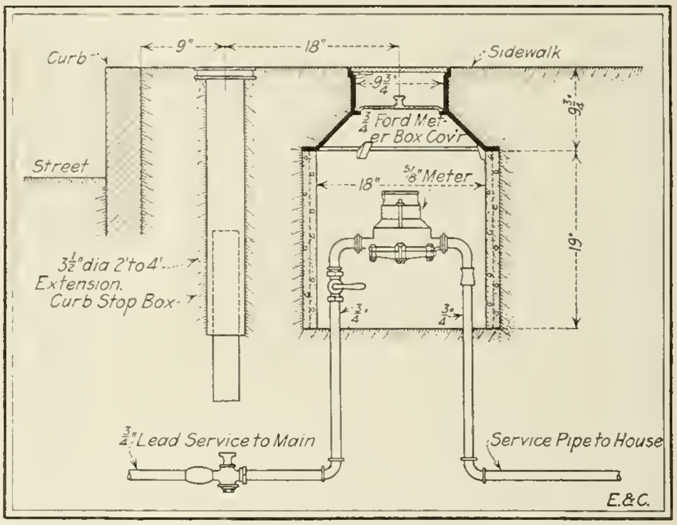


Fig. 3—Standard Curb Setting for ⅜-in. and ¾-in. Meters.

### Cost of Installation.

The following tabulation shows the expenditures on account of the Meter Extension Project from the time the work was started until June 30, 1915:

| | |
|---|---|
| Salaries | $ 770.00 |
| Labor—Meter setting | 17,487.61 |
| Labor—Paving | 1,655.27 |
| Meter purchases | 59,357.57 |
| Meter yokes, boxes and covers | 16,344.67 |
| Pipe and fittings | 7,803.70 |
| Equipment (tools, etc.) | 628.30 |
| Repairs and renewals to equipment | 489.03 |
| Supplies | 332.56 |
| Paving material | 770.60 |
| Other material | 235.65 |
| Miscellaneous | 613.02 |
| Total | $106,487.98 |

The average cost of installing ⅝-in. meters at the curb including meter, meter box, top, pipe and fittings as shown in the illustration of the department's standard installations (Fig. 3), was $12.84. This price includes the cost of repaving, but not the cost of the curb stop box or curb stop. The average cost of installing meters in the cellar or other inside location was $8.555, including all necessary labor and material.

The standard meter box was constructed of cinder concrete. These boxes were manufactured in large quantities by the department and to their use is due largely the low cost of curb installations.

While the box is but 19 in. deep, experiments conducted by the department are stated to have demonstrated that there is no danger of freezing in this climate from such comparatively shallow settings.

## LEAKAGE FROM PIPE JOINTS.

At the 1915 convention of the New England Waterworks Association a committee was appointed "to investigate experience in the leakage of pipe joints." In order to obtain information a circular containing 37 questions was mailed to 430 members of the association and to 124 members of the American Waterworks Association. From the 554 circulars sent out only 131 replies were received. In order to induce greater interest in the questions and to obtain additional information for the committee, Mr. F. A. Barbour, a member of the committee, submitted a paper at the Portland, Me., convention, in which he set forth some points obtained from the questionaire. Mr. Barbour's paper, in abstract, follows:

Of the 131 replies received, 10 per cent report the services to be entirely metered and 30 per cent more than 80 per cent metered, and the average water unaccounted for, as estimated in these systems, is 21 per cent. This loss is chargeable to leakage from mains or services, or to failure of the meters to register. It would seem to be worth while attempting to locate the cause of a 20 per cent loss of the water furnished. If slippage of meters is the explanation this simply means that consumers are getting more than they are nominally paying for, but if leakage from the mains and services is responsible, the result is an absolute loss of water, which costs money to develop and deliver to the distribution system.

The average consumption in the 40 systems in which 85 per cent or more of the services are metered is, as reported, 68 gal. per day per capita. The average estimated unaccounted for water was, therefore, equivalent to about 14 gal. per day per capita, or a loss of 5,000 gal. per year per capita, which, if the cost is estimated at $25 per million gallons of water delivered to the distribution system, is equivalent to a yearly cost per capita of 12½ ct., or approximately the interest on $2; in other words, a town of 10,000 people could afford to expend $20,000 in order to prevent this loss of 14 gal. per day per person.

If then in these fully metered systems, which undoubtedly represent the best condition, only 80 per cent of the water supplied is sold to the consumers, the question arises as to whether this should be accepted as the highest standard of efficiency which can be reasonably attempted. If, in any considerable part, the unaccounted for water is chargeable to slippage of meters, then it would seem desirable that increased attention should be given to the subject of maintained accuracy and sensitiveness of meters. If meter slippage is not the explanation of the unaccounted for water, then the loss must be through leakage from the mains or services.

As to the loss from services, 80 per cent of those replying to the circular estimate this to be small or none. As to the leakage from mains, 99 of the 131 answers received do not attempt to estimate this loss, 18 state it to be very small or none, and 14 estimate it in percentage of the total amount supplied, the average of these few figures being 15 per cent.

From the replies already received, therefore—and these presumably are from those departments best able to answer the several questions, or most interested in the problem—it is evident that while undoubtedly a considerable portion of the water supplied is not sold to the consumer, there is little or no definite knowledge of the actual conditions of the pipe joints. The general impression, as indicated, is that the mains are fairly tight and that the leakage from services is small. It may also be inferred from various notes in the replies received, that such leakage as may occur in mains is located at certain isolated joints and is not general.

One phase of the investigation as conceived by the committee was that in reference to the practice of testing pipes when laid. Believing that in the majority of cases local conditions would not permit the trenches to be kept open until the pipes were tested, the question was asked as to the reasonable allowable leakage in testing after back-filling, as determined by the measured water necessarily introduced to maintain the test pressure. Such a method of testing is of course not to be compared with the visual examination of the joints under pressure, but it is necessary in many cases.

Of the 131 replies received in reference to testing pipe when laid, 76 state that such tests are made, 36 that no tests are attempted, and 19 that sometimes the pipes are tested and sometimes not. The interesting and rather surprising feature in these replies is that all but six of those who state that the pipe is tested, report that the test is made before back-filling the trench. Further, of the 75 who replied to the question as to the standard of tightness required before putting the pipe in service, 63 state this requirement to be "absolute tightness." Of those who report that it is customary to test the pipe when laid, 85 per cent state that the test is made under the working pressure which the pipe is to carry in service. Only 18 report tests in excess of working pressure, the test pressures ranging from 30 lb. excess to double the working pressure.

From the information received to date, it therefore appears that it is quite the general practice to test before back-filling and to require absolute tightness under the working pressure. If these replies can be accepted as expressing the general practice of water departments, it is evident that the present standard is high, and the only question which might profitably be asked is as to what happens to the joints when the higher pressures due to water ram, and more or less incident to the operation of every system, are applied, and whether, therefore, pipes should not be tested at some pressure above that of working conditions. It is noticeable that but very few of the statements made in reference to leakage from mains and services are based on any actual tests after the pipes have been in use for any period of time, and the opinions expressed are generally formed from observation of such joints as have from time to time been exposed. Only four definite statements of tests for leakage of pipe after periods of use are reported, and these indicate only a small loss from the joints.

Naturally only those systems where a high percentage of the services are metered can make any accurate estimate of the water not delivered to consumers. Where less than 75 per cent of the services are metered, waste by carelessness inside the premises of consumers is undoubtedly the great factor in determining the amount of water supplied—a condition which clearly stands out in the replies received, by comparing the water furnished per capita with the per cent of metered services. Thus, with due allowance for special industrial demands, the relation between meters and amount supplied is very approximately, as follows:

| | | | |
|---|---|---|---|
| 100% | metered | 68 | gallons per day per capita. |
| 75% | metered | 75 | gallons per day per capita. |
| 50% | metered | 90 | gallons per day per capita. |
| 25% | metered | 110 | gallons per day per capita. |
| 0% | metered | 125 | gallons per day per capita. |

It is, therefore, evident, as would be expected, without the evidence of the present investigation—that in the conservation of our water supplies metering of the services is the great factor, and leakage from mains, except in particular instances, is of minor importance.

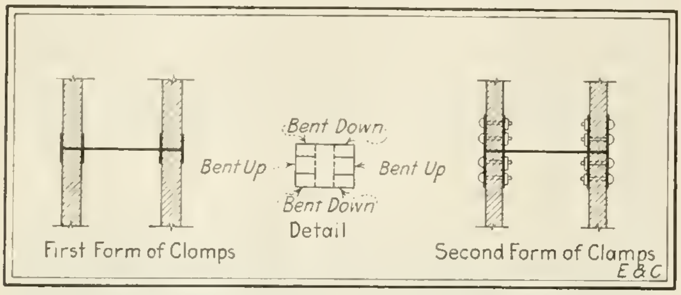
While this is true, however, there remains the fact that in completely metered systems the average unaccounted for water amounts to about 20 per cent of the total amount of water delivered to the distribution pipes.

Whether it is economically possible to reduce this loss by a better type of joint, better workmanship, testing at pressures above normal, cannot be determined by the evidence thus far made available to the committee. The information most needed to reach conclusions is that giving the results of leakage surveys, of actual tests made after the pipes have been in service some years, of experimental work showing the relation between pressure on the joints and leakage, and, particularly, data from those departments where accurate tests have shown leakage in mains to exist. There is no doubt that in many cases there is a large loss from the pipe system, even though in the replies received to date to the circulars of the committee the great majority regard this loss as very small, or refuse to make any estimate.

## WELLS CASED WITH VITRIFIED PIPE.

Vitrified sewer pipe was used for the casing in wells constructed recently for the towns of Barnstable and Medway, Mass. The pipe was sunk in the same manner that a caisson is put down. For the larger size wells the excavation was handled by a small orange peel bucket operated from a 4-leg pipe derrick, the material first being loosened with a long bar.

The bells of the pipe were cut off, and a system of clamps used for keeping the sections together and preventing off-setting. Two forms of clamps, as shown in the accompanying sketch, were used. The first type was made of metal plates with slits at each corner, so that the center section was bent up and the two side sections bent down. The use of this type depended entirely upon the weight of the pipe keeping the upper section following the next lower section properly.



Types of Clamps for Joining Pipe Sections.

In some kinds of ground this form of clamp was not satisfactory as the lower sections were liable to leave the upper sections. In this case straight steel clamps were used on the sides, with two bolts in each pipe and a plate outside and one inside.

The wells were about 30 ft. deep and as a substitute for small tubular wells have proved very effective. It has been found that a large supply of water can be drawn from quick sand by this method, after loading down the sand when it's rising. The wells were devised by L. L. Wadsworth, president, and Henry A. Symonds, engineer, of the Hanscom Construction Co., Boston, Mass. The wells cost about $200 each.

## EXPERIENCE AT SPRINGFIELD, MASS., IN THE APPLICATION OF COAGULANT INTERMITTENTLY IN EXCESS AMOUNTS.*

By Elbert E. Lochridge, Chief Engineer, Springfield Water Works.

Coagulation by sulphate of alumina prior to slow sand filtration has been the practice at the West Parish Filter plant of Springfield, Mass., since its construction. Records are now available covering six full years. During the last four years of this time the method of application has been so altered that materially reduced amounts of coagulant are necessary, although at all times it has been possible to produce satisfactory water. This method has been the application of over-doses of sulphate of alumina to the water intermittently. The filters, six in number, are of the slow sand type and of ½ acre area each. The water of Little River as it comes to the filters is that of a mountain stream usually clear, of low alkalinity, but with a varying color, which with the rise of the stream may increase several fold within a few hours. This color in the river water may be low enough for use without any reduction for a long period of time, when suddenly a rise in the stream will cause a large increase of color which makes the water objectionable for use.

In the chart (Fig. 1) the upper line represents the color of the river water by day, and the lower the color of the filtered water at the same time. These are plottings of daily results. The amount of sulphate of alumina in terms of both grains per gallon and pounds per million gallons is plotted above the color lines in such manner that the amount applied each day may be readily seen. This chart gives the comparison of the two-year period of 1910 and 1911, during which time coagulant was applied in the usual manner, with the years 1912, 1913, 1914 and 1915, in which the method to be described was used. The records for the six years are plotted in such manner that seasonal comparisons are also possible.

The Little River at the point of diversion has a catchment area of 48 sq. miles. Its elevation at this point is 496 ft. above sea level, and with steep slopes the ground rises to an elevation of from 1,500 to 1,700 ft. at the highest points of the watershed. The surface of the storage reservoir on Borden Brook is 1,070 ft. above sea level, and 1,000 ft. above Main St. in Springfield. The water is diverted from the stream in a deep and narrow gorge, and sent through a mile of tunnel to a sedimentation basin 8 acres in area with a capacity of 40,000,000 gal., or between three and four days' supply. From this small reservoir the water is drawn to the filters. The water from the tunnel is carried by a concrete conduit to an arm at the greatest distance from the outlet. There are no baffles or other artificial obstructions in this reservoir. The coagulant is applied in solution to the water in transit in the concrete conduit at a point which causes it to travel with the current 540 ft., permitting some mixing before its submerged delivery into the basin. Water is constantly flowing from the river to this basin through the conduit and is drawn uniformly from this basin to the filters.

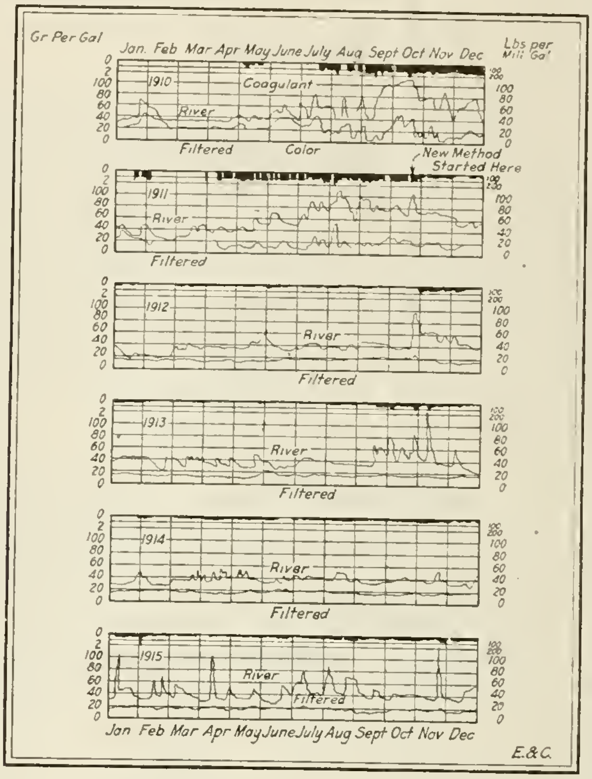


Fig. 1.—Coagulant—Grams per Gallon—Pounds per Million Gallons—Color—River and Filtered Water.

The determination of the amount of aluminum sulphate necessary for complete reaction is made in a series of 2-gal. bottles, from 15 to 20 in number, which are filled each day with the river water. To these are added, in uniformly varying increments, definite amounts of sulphate of alumina. For example, to the first bottle enough is added to give the effect of the rate of 50 lb. per million gallons; to the next, 60 lb.; to the next, 70 lb., and so on by 10 lb. per million-gallon increments to 270 lb. Within a few hours all of the bottles with amounts of coagulant in excess of the "reaction point" will indicate complete color removal, and the precipitation of foreign matter will be complete, while all bottles containing less coagulant than this amount will be in a cloudy or murky condition, indicating incomplete reaction. The determination is made in this manner each day, permitting a study of the effects of the rise and fall of the stream, the effect of storms, melting snows, etc. This information is also of great value at times of sudden changes, when there is insufficient time to make the determination. The amount necessary is dependent on a number of different conditions. With waters of the same alkalinity there may be quite a marked difference in the amount necessary for reaction, varying with river conditions. It is not entirely dependent on the amount of color, as with the same color to be reduced it varies on different days. The amount of coagulant actually applied to the water is always a little in excess of the reaction point determined, and during the period of application this is kept as nearly constant as possible.

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*Abstract of a paper presented Sept 13 at Convention of the New England Water Works Association. The paper in full will appear in the Journal of the Association.

With the amount or rate of coagulant application per hour thus known, it is still necessary to determine the number of hours per day during which it shall be added. Throughout most of the year, from four to six hours per day is sufficient, but at a time of flood, resulting in a very material increase in color, this period may be lengthened to twelve hours, or 50 per cent of the time.

Generally speaking, the standard set for filtered water is that of no coagulation if the color does not exceed 25. Before the filtered water reaches this figure, coagulant is resorted to, and during such application the color is to be kept at 20 or below. By referring to the accompanying diagram it will be seen that, since the adoption of this method, it has been possible to make the line of color in the filtered water substantially straight or uniform throughout the year. Under the old method of constant coagulant use, it was found impossible, especially at times of low alkalinity or sudden changes, to add sufficient sulphate of alumina to reduce the water to a satisfactory color at all times. The addition of soda ash or lime was necessary for restoring alkalinity at such times. This is entirely unnecessary with the intermittent application, as but a small portion of the alkalinity is used in the formation of the floc. The first coagulation in the conduit and basin results in a water of substantially zero color, with at least a theoretically slightly acidic reaction. This treated portion of the water, which has entered the basin chemically active, with the precipitate or floc forming rapidly, is then followed by untreated water in a quantity, because of the longer period of time, in excess of the treated water.

The thorough mixing of this raw water with the treated water is brought about at the outlet of the submerged conduit as it displaces the basin water at this point. The second reaction begins at once and is carried to completion with a restoration of alkalinity to the entire supply, this action probably being consummated during the period which elapses before the next application of coagulated water. The floc of the treated water has not had an opportunity to settle when the raw water is admitted, and readily furnishes a base about which the additional precipitation resulting from this secondary reaction forms, and serves to carry down color, sediment, and bacteria mechanically, as well as through the chemical reaction which is taking place in every part of the untreated water as it mixes with the overdosed water.

The resultant reduction of color is, therefore, due to the effect of dilution of the higher colored water with water of no color; to the second reaction, which is, in reality, the completion of a reaction started under favorable conditions of overdosing, and which reaction chemically is always complete, as the excess of the applied coagulant is taken up by the alkalinity of the untreated water, resulting in the completion of the mass reaction; and also to the mixing of the floc of the fully treated portion with the mass of the entire day's water supply, before it has the opportunity to settle. The precipitate thus formed in a large part settles before it is carried to the filters.

The sedimentation basin was drawn off and cleaned after five years' operation of the filtration plant, and it was found that large masses of precipitated organic matter and aluminum hydrate had settled in the upper portions of the basin. This deposit covered the entire basin, varying from 3 to 4 ft. in depth near the inlet to a few inches in proportion to the distance from the point of entry to the basin of the raw water.

The average length of filter runs during the four years described in this paper of the use of this process were as follows:

TABLE I.

| Year. | Filter runs after scraping. | | | Filter runs after raking. | | |
|---|---|---|---|---|---|---|
| | Number. | Average in millions of gallons per ½-acre bed. | Maximum runs in millions of gallons. | Number. | Average in millions of gallons per ½ acre bed. | Maximum runs in millions of gallons. |
| 1912.......... | 22 | 76 | 90 | 26 | 76 | 84 |
| 1913.......... | 22 | 95 | 115 | 23 | 79 | 91 |
| 1914.......... | 26 | 85 | 152 | 24 | 77 | 157 |
| 1915.......... | 29 | 89 | 229 | 21 | 42 | 104 |

In conclusion, it may be said that the use of intermittent coagulation results in a saving in expense, uniform results of satisfactory quality, coagulation without exhausting alkalinities in soft waters, and coagulation without excessive overloading of the precipitated hydrate on the filter beds.

## METHOD OF TAPPING A 6-FT. MAIN INTO CONCRETE AND STEEL SHAFT UNDER PRESSURE.

Contributed by James Skelton, 70 Lawton Ave., Toronto, Canada.

In making extensions to the water works system of the city of Toronto, in the spring of the year 1914, it was found necessary to tap, at a point 40 ft. below the surface of the ground, the vertical shaft through which was being drawn the entire water supply of the city. A new 6-ft. main was to be connected; and, as it was earnestly desired that the work should be done without closing down the pumps, the job was one which called for original ideas and considerable engineering skill. It is to the credit of Superintendent Margerison of the Marine Section, who had the work in charge, that he solved the problem in a manner at once simple and effective.

The tunnel shaft, on which the operation was to be performed, consisted of a steel pipe 10 ft. in diameter and encased in concrete, which extended vertically downward into the rock, a distance of 90 ft., to a point where it united with the horizontal tunnel which leads under the bay and across the island and out into the deep waters of the lake. It was proposed to place a cofferdam on the inside, over the area affected, and to cut into the shaft from the outside.

In constructing the cofferdam—which was, of course, built above ground and placed in position afterwards—a platform was first made, 80 ft. square, of solid oak planking. On the upper side of this, flush with the four edges, were bolted four 10-in. squared timbers. And on top of these—on the two end ones—were spiked two similar timbers, each 8 ft. in length, which had been sawn semi-circular in shape along one side so as to conform to the cross-section of the pipe; and the outside edges of the two side timbers were beveled so that they also would fit snugly against the curved walls of the shaft. To make all water-tight, a thick rubber gasket was inset on the face of the timbers on all four fronts.

On the reverse side of the platform, an upright A-brace of squared timbers was bolted, its feet flush with the two sides and midway between the two ends, the total height of the dam with the brace in position being a trifle less than 10 ft. A horizontal bench-brace straddled the platform at right angles to the A-brace, between the legs, its height 20 in. less than that of the A-brace.

The cofferdam was not complete. It was heavily weighted, so as to counteract its buoyancy, and then hoisted by derrick and let down through the roof of the pumping station into the pumping shaft.

Into the black waters of the shaft Superintendent Margerison descended; and the dam was carefully lowered to the required depth, and guided over the exact spot to be covered. Here it was temporarily anchored, a wedge being driven between the apex of the A-brace and the tunnel wall. Two heavy jacks were then adjusted, their bases against the shoulders of the horizontal bench-brace, their tops against the tunnel wall. A little at a time the jacks were carefully tightened and the wedge driven home. Four hours from the time the derrick swung it aloft the cofferdam was in place.

Beside the tunnel shaft an excavation had been made in the rock to a depth of about 50 ft., and workmen immediately set to work to chisel away the 12-in. concrete jacket at the point where the main was to enter. The steel lining being exposed, the 6-ft. shield of metal was cut away by means of an oxyacetylene flame. The dam was found to be absolutely water-tight.

A steel flange was riveted in place, and a length of pipe connected thereto, after which a big valve was installed. Flange, pipe and valve were then encased in cement. The valve was closed and the cofferdam removed.

While the dam remained in position, the great pumps were raising through the shaft their usual average of 65,000,000 gal. of water per day, sufficient for the needs of a city of half a million people. Had they had to be closed down at frequent intervals it would have meant much inconvenience to the consumers.

## COST AND USE OF CHEMICALS AT PURIFICATION PLANT OF ST. LOUIS, MO.

The entire water supply of the city of St. Louis, Mo., is pumped from the Mississippi River at the Chain of Rocks into seven settling basins, having a total capacity of about 200,000,000 gal. Sedimentation is hastened through the addition of lime and sulphate of iron. The water is then passed through rapid sand filters having a total rated capacity of 160,000,000 gal. for 24 hours, and is delivered by gravity through conduits to high service pumping stations. Part of the new Chain of Rocks filtration plant was placed in service on May 15, 1915, and the plant was completed in November, 1915. The method of purification is as follows: Grit removal, softening with lime, coagulation with iron, sedimentation, coagulation with sulphate of alumina, filtration and sterilization with chlorine. The following data on the operation of the purification plant for the year ending April 1, 1916, are taken from the recently issued annual report of Edward E. Wall, Water Commissioner of St. Louis.

During the past year, 34,690 million gal. of water were pumped into the basins. To this amount of water were added 4,471 tons of sulphate of iron and 13,790 tons of lime, or an average of 1.84 grains per gallon of the former chemical and 5.57 grains per gallon of the latter.

To the 29,823 million gal. of water filtered were added 1,225 tons of sulphate of alumina and 57,781 lb. of chlorine, or an average of 0.672 grains per gallon of the sulphate and 1,934 lb. per million gallons of the chlorine. The aluminum sulphate was added before filtration and the chlorine after.

The yearly maxima, minima and averages of the sulphate of iron and lime used in grains per gallon since the installation of the process and the total quantities of lime and sulphate of iron used during the same period are shown in Table I.

TABLE I.

Lime.

| Year. | Grains per gallon<br>Maximum. | <br>Minimum. | <br>Average. | Total tons. |
|---|---|---|---|---|
| 1904-1905 | 9.00 | 4.00 | 6.02 | 14,291 |
| 1905-1906 | 10.00 | 5.00 | 6.28 | 11,814 |
| 1906-1907 | 10.50 | 3.00 | 7.39 | 14,081 |
| 1907-1908 | 9.75 | 4.00 | 6.02 | 12,063 |
| 1908-1909 | 8.00 | 4.75 | 5.58 | 11,611 |
| 1909-1910 | 8.25 | 4.50 | 5.70 | 13,044 |
| 1910-1911 | 7.25 | 4.00 | 5.77 | 13,032 |
| 1911-1912 | 8.50 | .... | 5.19 | 12,665 |
| 1912-1913 | 6.50 | 4.00 | 5.23 | 12,448 |
| 1913-1914 | 7.50 | 4.25 | 5.63 | 12,871 |
| 1914-1915 | 7.50 | 4.00 | 5.75 | 13,660 |
| 1915-1916 | 7.25 | 3.50 | 5.57 | 13,790 |
| Sulphate of Iron. | | | | |
| 1904-1905 | 5.00 | .... | 1.52 | 3,578 |
| 1905-1906 | 5.00 | .50 | 2.20 | 4,138 |
| 1906-1907 | 4.75 | 1.25 | 2.13 | 4,050 |
| 1907-1908 | 4.25 | .... | 2.55 | 5,117 |
| 1908-1909 | 4.25 | 1.75 | 2.41 | 5,013 |
| 1909-1910 | 4.50 | 1.50 | 2.91 | 6.649 |
| 1910-1911 | 4.00 | 1.75 | 2.70 | 6,098 |
| 1911-1912 | 4.50 | .... | 3.35 | 8,094 |
| 1912-1913 | 4.50 | 1.75 | 2.97 | 7,082 |
| 1913-1914 | 4.25 | 1.00 | 2.49 | 5,816 |
| 1914-1915 | 4.50 | 1.25 | 3.00 | 6,770 |
| 1915-1916 | 3.75 | .... | 1.84 | 4,471 |

TABLE II.—COST PER MILLION GALLONS, BASED ON CONSUMPTION.

| Old Plant— | 1911-12. | 1912-13. | 1913-14. | 1914-15. | 1915-16. | Nov.,'15, to Apr.,'16. |
|---|---|---|---|---|---|---|
| Lime | $1.83 | $1.73 | $1.87 | $1.61 | $1.70 | $1.61 |
| Iron | 2.73 | 2.42 | 1.92 | 2.02 | 1.42 | .64 |
| Unloading | .10 | .12 | .11 | .10 | .08 | .07 |
| Operating, maintenance and repairs | .37 | .44 | .42 | .35 | .47 | .51 |
| Water, coal, oil, etc. | .05 | .05 | .05 | .04 | .03 | .04 |
| Light and power | .08 | .05 | .04 | .03 | .07 | .07 |
| Chemical work | .21 | .29 | .28 | .25 | .43 | .49 |
| Basin cleaning | .07 | .10 | .07 | .12 | .14 | .08 |
| Basin repairs | ... | ... | ... | ... | .03 | .03 |
| Total old plant | $5.44 | $5.19 | $4.80 | $4.56 | $4.37 | $3.54 |
| Filters— | | | | | | |
| Aluminum sulphate | ... | ... | ... | ... | $0.76 | $1.00 |
| Chlorine | ... | ... | ... | ... | .18 | .15 |
| Operating, maintenance and repairs | ... | ... | ... | ... | .83 | .98 |
| Coal, miscellaneous supplies and exp'ses. | ... | ... | ... | ... | .14 | .26 |
| Light and power | ... | ... | ... | ... | .14 | .15 |
| Total | ... | ... | ... | ... | $6.42 | $6.08 |
| Total consumption for year in million gals. | 30,506 | 29,956 | 30,927 | 33,971 | 32,583 | 13,138 |
| Cost of Chemicals— | | | | | | |
| Lime, per ton | ..... | ..... | $4.61 | $3.48 | $3.65 | ..... |
| Sulphate of iron, per ton | $10.00 | $10.00 | 10.00 | 10.00 | 10.00 | ..... |
| Sulphate of alumina, per ton | ..... | ..... | ..... | ..... | 16.80 | ..... |
| Chlorine, per lb. | ..... | ..... | .10 | .10 | .08 | ..... |

The average cost per million gallons for lime was $1.70, for sulphate of iron $1.42, for sulphate of alumina (10½ months) 76 ct. and for chlorine 18 ct. These costs are for chemicals alone and do not include the cost of handling or application. A comparison of the costs of the various parts of the purification work during the past five years based on the quantity of water delivered to consumers is shown in Table II.

Under the head of lime, iron, sulphate of alumina and chlorine are included all charges connected with the switching of these materials from the interchange tracks at Bissell's Point and Humboldt Ave. to the Chain of Rocks.

The complete purification system was not in use until Oct. 11, 1915, when the grit chamber and mixing chamber were put into service. The average number of grains per gallon of lime and sulphate of iron used, from Nov. 1 to March 31, was 5.21 of the former and 0.83 of the latter. During the same period of the preceding year, the average number of grains of lime used was 5.25 and of sulphate of iron, 2.05. The saving effected by the use of 1.22 grains less of sulphate of iron represents a saving of $12,178, or 88 ct. per million gallons for each of the 13,839 million gal. of water pumped during the above period.

The average cost of filtration, as shown in Table II, for the period, Nov. 1 to March 31, was $2.54 per million gallons, an increase in cost above the saving effected by the use of less iron of $1.66 per million gallons. For this greater cost a water of sparkling clearness, of little color and of greater purity has been furnished the consumer.

The past year has been marked by an unprecedented high average stage of the river. This high stage made the treatment of the water very difficult and made necessary the use of a larger amount of chemicals than would have been used had the stages been as of the preceding year. During the months prior to November the basins were being withdrawn from service at times in order to permit construction work to be carried on with consequent derangement of operation and higher chemical charges required and for a time during the summer the river stages prevented any cleaning and consequently higher chemical charges were required than would have been the case in normal operation. A larger saving in chemicals may be expected during the year 1916-1917.

The sulphate of iron, in the form of sugar sulphate, was furnished by the American Steel and Wire Co., at price of $10 a ton. The price per ton has been the same since May, 1907.

Liquid chlorine, at a price of 10 ct. and later at 8 ct. a pound, was supplied by the Electro Bleaching Gas Co. The chlorine was delivered in cylinders containing 100 lb. of liquid.

Sulphate of alumina was purchased under the following specifications: "The basic sulphate of alumina shall be crushed into small lumps, ranging in size from ½ in. to 2 in. It shall contain not less than 17 per cent of available water soluble alumina, $Al_2O_3$.

"There shall be at least ½ of 1 per cent of alumina, $Al_2O_3$, in excess of the amount theoretically required to combine with the sulphuric acid present. The material shall not contain more than 1/10 of 1 per cent of matter insoluble in cold water. It shall not contain more than 1 per cent of iron."

The sulphate of alumina was furnished, under the terms of this specification, by the General Chemical Co. at a price of $16.80 per ton. A requisition was drawn for 2,000 tons. All cars of sulphate received have passed the above requirements.

The contracts for lime were let under the same specifications as last year, requiring a lime of 85 per cent CaO with a bonus and penalty of 1½ per cent of the contract price for each per cent of CaO above or below the required 85 per cent. All lime was sampled as it came from the crusher after unloading. The car samples and samples from the daily supply hopper were analyzed in the laboratory.

Two requisitions were drawn for 6,000 tons each. The successful bidders were the Glencoe Lime & Cement Co. at $3.84 a ton, and the John Armstrong Lime & Quarry Co. at $3.68 a ton. The average price paid per ton on all deliveries since July from the former has been $3.90, from the latter $3.40, from both $3.65; the average per cent of lime, CaO, present being 84.1. During a similar period last year the average price paid per ton was $3.48, the average per cent of lime being 85.1. The contract prices were $3.64 and $3.50 per ton on two requisitions of 7,000 tons each.

## STATISTICS OF STORAGE OF FILTERED WATER.

The accompanying tabulation from the recently issued report of Messrs. Hyde, Wilhelm and Miller on a new water supply for the city of Sacramento, Cal., shows the provisions that have been made for the storage of filtered water at several plants in the United States. The table indicates that the percentage relation of capacity of storage to the nominal daily volume of output of the plant represented varies from a maximum of 91 per cent to a minimum of 3 per cent and averages 30 per cent. Similarly, with respect to hours of storage represented by the capacity of the filtered water basins when the filters are operating at their nominal capacities, the maximum value is 21.8 hours, the minimum 0.7 hours and the average 7.1 hours. The statistics of storage are as follows:

| Name of place. | Nominal capacity.* | | Nominal hours† of storage. | Percentage filter cap.‡ to F. W. basin cap. |
|---|---|---|---|---|
| | Filters 1,000,000 gal. daily. | Filtered water basins 1,000,000 gal. | | |
| Minneapolis, Minn. | 55 | 50 | 21.8 | 91 |
| Philadelphia, Pa. (Schuylkill Riv.). | 115 | 77.5 | 16.2 | 67 |
| New Orleans, La | 40 | 15 | 9.0 | 38 |
| Columbus, O. | 30 | 10 | 8.0 | 33 |
| Louisville, Ky. | 75 | 25 | 8.0 | 33 |
| Pittsburgh, Pa. | 165 | 50 | 7.3 | 30 |
| Philadelphia, Pa. (Delaware Riv.). | 182 | 50 | 6.6 | 27 |
| Evanston, Ill. | 12 | 2.5± | 5.0± | 21± |
| Cincinnati, O. | 112 | 19.5 | 4.2 | 17 |
| Cleveland, O. | 150 | 25 | 4.0 | 17 |
| Baltimore, Md. | 128 | 17.8 | 3.3 | 14 |
| Grand Rapids, Mich. | 21 | 2.8 | 3.2 | 13 |
| Little Falls, N. J. | 33 | 3.5 | 2.5 | 11 |
| New Milford, N. J. | 35 | 2.0 | 1.4 | 6 |
| McKeesport, Pa. | 6 | 0.3 | 1.2 | 5 |
| Harrisburg, Pa. | 15 | 0.02§ | 1.0 | 4 |
| Albany, N. Y. | 21 | 0.6¶ | 0.7 | 3 |
| Totals | 1,195 | 352.12 | .... | .. |
| Averages | 70 | 21 | 7.1 | 30 |
| Proposed for Sacramento | 30 | 5 | 4 | 17 |

*Arbitrarily taken at 125 million gal. per acre per day for rapid sand filter plants and 3 million gal. per acre per day for slow sand filter plants. This assumption is reasonable for the former type of plant, but may be much too low for the latter type, if the water has received adequate preparatory treatment, and especially, also, if chlorination of the effluent is practiced.

†Nominal hours of storage in filtered water basins when filter plant is operating at its nominal capacity.

‡Percentage of nominal daily capacity of filters represented by the capacity of the filtered water basins.

§From this reservoir water is pumped to an elevated open distributing reservoir of 20,000,000 gal. capacity.

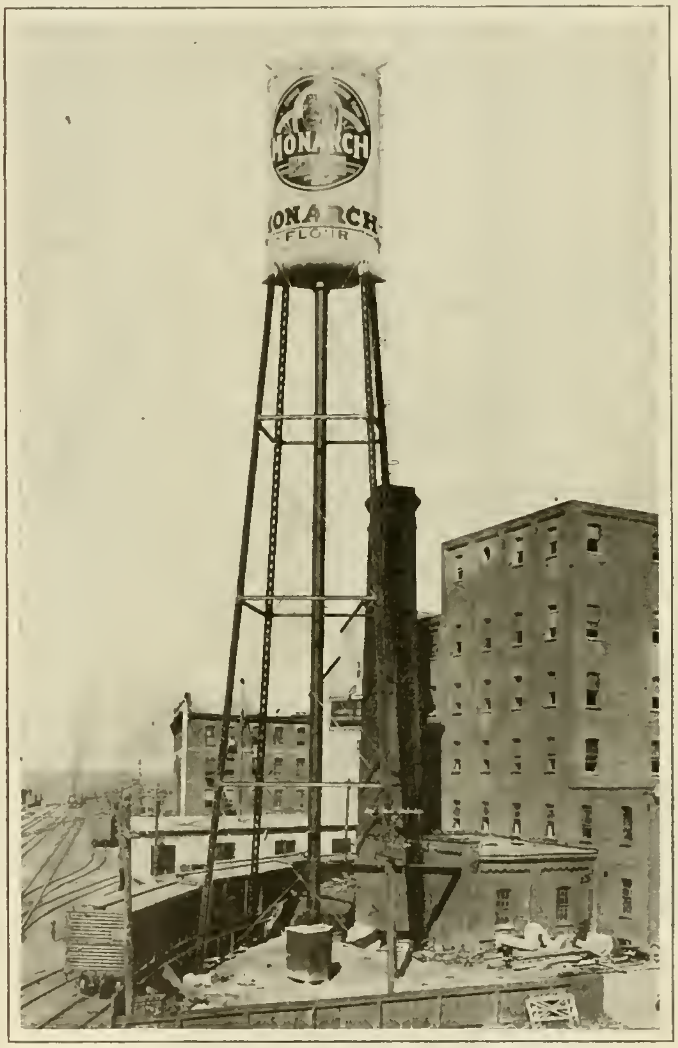
¶From this reservoir water is pumped to reservoir holding 37,000,000 gal.

## AN UNUSUAL FORM OF ELEVATED WATER TANK.

(Contributed.)

The accompanying view illustrates a large elevated water storage tank built for the Campbell Flour Mills Co., Limited, of Toronto, Ontario. Their flouring mills, which rank among the most progressive in Ontario, were recently equipped with an automatic sprinkler system to provide fire protection and reduce their insurance rates. The tank is used for the storage of water necessary to operate the sprinkler equipment satisfactorily.

The prominent position and great height of the structure renders it peculiarly effective for advertising purposes, and the company has taken advantage of this fact in having the tank built in replica of a bag of flour. The work is built entirely of steel, which material may be readily formed to the shape desired and at the same time insures great strength and unusually long life. The tank was painted and lettered to represent exactly the sack in which the company's product is marketed.



An Elevated Water Tank Built in Semblance of a Flour Bag.

Some idea of the size of this water tower may be gathered from the following data: The tank holds 40,000 gal. of water. The total height of the structure is 152 ft. above foundations. The tank itself is 37 ft. deep and 18 ft. wide, being built oval in cross-section to correspond truly to the shape of a flour sack. The weight supported is over 200 tons.

The work was designed and executed by the Canadian Chicago Bridge & Iron Co. of Bridgeburg, Ont., which makes a specialty of this class of construction. They have also recently constructed in the city of Toronto for the City Dairy Co. a similar structure having a tank in the shape of a milk bottle.

# THE SCIENTIFIC CLEANING OF SETTLING BASINS.*

By Alexander Potter, Consulting Engineer, New York City.

A number of settling basins have been constructed by the writer in the last ten years in which the sludge deposits are removed at frequent intervals through small perforations built in the bottom of the basin, and without interfering with the settling process, which is carried on continuously. The first plant of any size in this country in which this principle of a perforated bottom was used, was that at McKeesport, Pa., a plant designed to treat 10,000,000 gal. of water daily.

The conditions at McKeesport are at times especially trying on the sludge removal apparatus, for there are periods, of short duration, when the precipitation reaches almost 10 per cent by volume of the water treated, and in the treatment 1,000,000 lb. of lime and 1,500,000 lb. of soda ash have been used annually. The cost of removing the precipitated material at the McKeesport plan has averaged about 35·ct. per 1,000,000 gal. of water treated. The ratio of blow-off water to water treated ranges from 1.4 to 8.9 per cent when the water is bad, and averaged 2.3 per cent for the period that the plant has been in operation.

The largest settling basin built by the writer in which this method of sludge removal was used is the 6,000,000-gal. settling basin at Muskogee, Okla., completed in 1912 and described in the Proceedings of the American Water Works Association of that year.

In examining the performance of the McKeesport plant it was found that about 75 per cent of the precipitation took place in the first quarter of the tank; consequently, in designing the Muskogee plant the perforated bottom extended over 25 per cent of the tank, and at this point a curtain wall was constructed and the water was forced to pass over the top of it. Experience has justified the decision of the writer, for examinations made on two occasions in the 3½ years that the plant has been in operation showed the amount of deposit in the unperforated portion of the settling basin varied from a depth of 3 in. at the curtain wall to 1 in. or 1½ in. at the far end.

When the Muskogee work was undertaken the writer was again warned of the probable failure of the sludge removal system, notwithstanding the success attending its installation at McKeesport, the argument being raised at that time that, whereas the MceKesport precipitate was a flocculent precipitate, due to the high chemical content, the precipitate at Muskogee, being of a silty nature, the perforations would undoubtedly become clogged. To date no such condition has arisen.

As this method of sludge removal is still considered by many engineers as impractical, the 3½ years' experience at Muskogee with this method of sludge removal should prove interesting.

## Muskogee Settling Basin.

The Muskogee settling basin is constructed of reinforced concrete. It is 212 ft. square and 19.5 ft. deep. When filled to a depth of 18 ft. its capacity is 6,000,000 gal. A reinforced concrete curtain wall, 6 in. thick, supported by buttresses at intervals of 12 ft., divides the basin into two compartments. The first and smaller of these compartments, 52.5 ft. wide and 212 ft. long (about one-quarter of the basin), has its bottom perforated and underdrained for sludge removal. To underdrain the larger compartment was not considered advisable, first, because of the expense and, second, based upon the experience in other plants where the writer adopted this method, it was not considered necessary because of the relatively small quantity of suspended matter which experience indicated would settle out in this compartment. Three and a half years' continuous operation shows it to average about 1.3 per cent as opposed to 98.7 per cent removed over the area with the perforated bottom.

Figure 1 is a section of the Muskogee settling basin taken parallel to the direction of flow. The raw water, treated with sulphate of iron and hydrated lime at the average rate of 1 and 2½ grains per gal., respectively, enters the settling basin at the left through the distributing trough. From the distributing trough the water is admitted to the first compartment of the basin through 32 8-in. circular openings. A vertical concrete baffle wall, 4 in. thick, constructed directly in front of these openings, tends to arrest all eddy and vortex motion and at the same time deflects the incoming water downward.

The partially settled water passes from the first to the second compartment over a submerged weir formed by the curtain wall. The crest of this submerged weir is about 6 in. below the average water level maintained in the tank. To assist in arresting vortex motion set up in the water as it passes over the submerged weir, a 4-in. stilling wall has been placed in front of it. The settled water is drawn off into the collecting channel over a series of weirs. The water level in the basin operated varies between elevation 527.5 and 528.0.

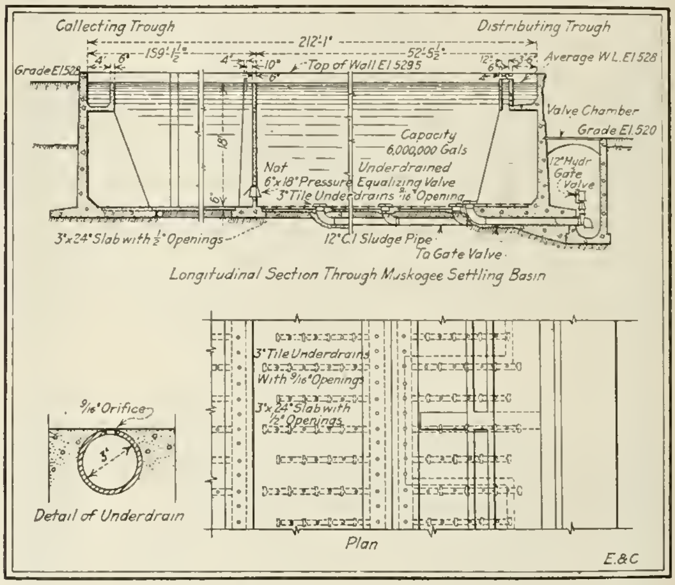


Fig. 1.—Longitudinal Section Through Muskogee Settling Basin. Detail of Drain and Plan.

To remove the sludge from the first compartment, 3-in. bell-and-spigot vitrified-stoneware drain-pipes have been laid in the concrete floor, which is 9 in. thick. These drain-pipes are arranged in parallel rows 27.5-in. centers in five distinct zones. These zones are laid out with the view of having the sludge deposited uniformly over the area of any one zone. Each zone consists of a main collecting channel 8 in. wide and 4 in. deep into which the 3-in. under-drains discharge. The 3-in. under-drains are made up in 2-ft. lengths and each length is perforated with one circular hole 9/16 in. in diameter. The cover plates of the main collecting channel are perforated with ½-in. circular holes spaced 13¾ in. centers. Twelve-inch cast iron pipes convey the sludge from the various zones to the sludge well. Tributary to each zone are 315 holes or perforations 9/16 in. in diameter, and 180 perforations ½ in. in diameter, giving a total area of 113.4 sq. in.—practically the same as the area of a 12-in. outlet pipe.

## Operating Results.

The plant treats an average of 3,000,000 gal. per day. The total solids in the raw water, which is taken from the Grand River, average 451 parts per million. This is increased by 64 parts per million by the hydrated lime and sulphate of iron applied to the water before it enters the settling basin. Of the total solids in the water after being treated with the chemicals, 44 parts per million settle out in the mixing chambers and distributing troughs, 307 parts per million in the first compartment, i. e., the first quarter of the settling basin, and only about 4 parts per million in the second compartment.

The collecting trough, as constructed, acts as a settling basin and tends to fill with sediment, thereby interfering to some extent with the uniform distribution of the coagulated water. Although much of this sediment is washed into the basin by the increased velocity set up in the distributing trough when the sludge valves are opened, periodic hand-cleaning is essential to secure the best results. Hand-cleaning could be avoided by reducing the area of cross-section of the trough and shifting the circular openings from the side to the bottom.

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*Abstract of paper presented Oct. 10 at the 23rd Annual Convention of the American Society of Municipal Improvements.

The total solids in the settled water amount to 160 parts per million, practically all of which is in solution. The water after it leaves the settling basins is, with very few exceptions, uniformly clear and free from suspended matter. The Grand River water is comparatively free from miscroscopic particles of clay. Very rarely, however, due to abnormal hydraulic conditions, the Arkansas River water finds its way up into the Grand River, and then difficulties are experienced in coagulating and removing these microscopic particles of clay nearly always present in the water of the Arkansas River.

The average rate of removal in the second compartment, based upon the total amount of solid matter collected in the second compartment when the basin was emptied for cleaning after two and a half years of continuous operation, averaged about 4 parts per million, which represents 1⅓ per cent of the total solids removed by settling.

As the Muskogee plant treats an average of 3,000,000 gal. of water per day, the weight of the dried solid matter which accumulates daily in the first compartment amounts to 7,690 lb. This solid matter is highly diluted with water and forms a very thin sludge which is neither sticky nor gelatinous but resembles a fluid of very low viscosity.

The daily accumulation of sludge, based upon a water content of 90 per cent, covers the first compartment to a depth of 1.25 in. in 24 hours. At this rate of deposition the first compartment would be half-full of sludge in 130 days, making due allowance for the compressibility of the sludge. In the 3½ years of continuous operation of this basin the settling basin has been out of commission but once for examination, at which time there were removed about 3 in. of sediment deposited in the larger compartment. The first, and underdrained, compartment was at that time found to be practically free from any considerable quantities of sludge, and no clogged perforations or drains were detected.

The following table gives the most important facts relative to the operation of the sludge removal system at Muskogee.

TABLE I—DATA RELATIVE TO SLUDGE REMOVAL.

| | |
|---|---|
| Average total weight of dry solids removed daily by underdrains in the form of sludge, lbs. | 7,690 |
| Average water content of sludge as discharged through blow-off valves, per cent | 98.7 |
| Total quantity of sludge water discharged at one operation, gal. | 70,000 |
| Ratio of blow-off water to total water treated, per cent | 2.33 |
| Effective hydrostatic head for sludge removal, feet | 20.5 |
| Average velocity thru underdrain perforations, feet per sec. | 20.4 |
| Loss of hydrostatic head through perforations, 26.3% of total head, feet | 5.4 |
| Hydrostatic losses in underdrain system, 21% of total head, feet. | 4.3 |
| Velocity head lost at discharge, 52.7% of total head, feet | 10.8 |

## Cost of Sludge Removal.

The total cost of constructing the sludge removal system for the Muskogee settling basin over and above the cost of constructing a plain tank of similar shape and size, and including all piping, valves, sludge chamber, etc., was $3,570. This is at the rate of 32.5 ct. per square foot of bottom underdrained. The average annual cost of operating and maintaining the sludge removal system, including all fixed charges, amounts to $523, and is made up as follows:

TABLE II.

| | |
|---|---|
| Interest and depreciation, 8% on $3,570 | $286 |
| Value of the blow-off water lost, 25,500,000 gallons raised 70 feet at $6 per million (including fixed charges) | 103 |
| 4,260 lb. ferrous sulphate lost with blow-off water at 1.25 ct. per lb. | 53 |
| 9,370 lb. hydrated lime lost with blow-off water at 0.005 ct. per lb. | 47 |
| Attendance and supplies | 34 |
| Total annual cost | $523 |

Total quantity of water treated, 1,970,000,000 gal.
Cost of sludge removal per 1,000,000 gal. of treated water, $0.49.
Weight of dry solid matter removed in one year, 1,404 tons.
Cost per ton of dry solid matter removed, $0.37.

The above costs of sludge removal compare most favorably with the cost of sludge removal as practiced on a large scale at St. Louis, Nashville and Kansas City. The costs of removing sludge given in the following table are taken from the municipal records, which, unfortunately, are not complete in that they only give the cost of labor, making no charge whatever for water lost and used in flushing out the basin. A fair allowance has been made in these costs for water wasted and used for flushing purposes, and as corrected, the data are sufficiently accurate for purposes of comparison.

TABLE III.—COST OF REMOVING SLUDGE FROM SETTLING BASINS.—(EXCLUSIVE OF FIXED CHARGES.)

| City. | Year. | Water treated (mil. gal.). | Sludge removed (cu. yd.). | Cost per cu. yd. of sludge removed. |
|---|---|---|---|---|
| *Muskogee, Okla. | 1913-1916 | 3,210 | 21,903 | $0.0469 |
| *McKeesport, Pa. | 1908-1913 | 8,890 | 96,000 | 0.0325 |
| Main basin | 1907 | 28,048 | 114,256 | 0.043 |
| St. Louis, Mo.: | | | | |
| Main basin | 1908 | 29,156 | 135,108 | 0.048 |
| Main basin | 1909 | 34,201 | 129,035 | 0.051 |
| Main basin | 1910 | 33,910 | 182,500 | 0.045 |
| Bissels Point basin | 1908 | ...... | 4,000 | †0.133 |
| Baden storage reserv. | 1908 | ...... | 700 | †0.213 |
| Nashville, Tenn. | 1908 | ...... | 4,500 | †0.359 |

*Settling basins have underdrainage systems.
†Labor costs only.

At St. Louis it appeared to have been the practice of lengthening the period during which a settling basin may be kept in service by opening the mud gate 5 or 6 in. daily for a period of about an hour, or until the effluent is comparatively clear. None of this flushing water has been charged up against the cost of sludge removal. It is estimated that during the year 1910 approximately 193,000,000 gal. of water were used for this purpose in 175 days. Including the cost of pumping and treating this flushing water with chemicals, the cost of sludge removal becomes 29.3 ct., which is about the same as the cost of removing the sludge at Muskogee.

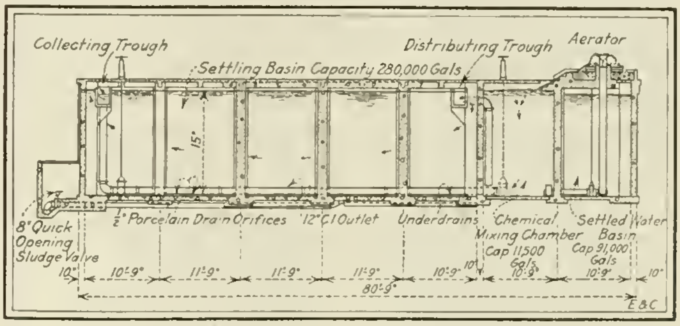
Collecting Trough
Distributing Trough
Aerator
Settling Basin Capacity 280,000 Gals
15'
8" Quick Opening Sludge Valve
½" Porcelain Drain Orifices
12" C.I. Outlet
Underdrains
Chemical Mixing Chamber Cap 11,500 Gals
Settled Water Basin Cap 91,000 Gals
10"
10'-9"
11'-9"
11'-9"
11'-9"
10'-9"
10"
10'-9"
10'-9"
10"
80'-9"
E&C

Fig. 2.—Section Through Settling Basin of Moorestown Deferrization Plant.

At Muskogee the percentage of sludge water to total water treated is 2.33 per cent, which, in the writer's opinion, can be considerably reduced by careful management. This ratio of sludge water to total water treated compares quite favorably with that of St. Louis, where in 1910, the only year for which accurate data are available, 523,000,000 gal. of water were chargeable against sludge removal. Of this amount, 300,000,000 gal. were lost in emptying the basin, 130,000,000 gal. were used for flushing purposes, and 193,000,000 gal. were wasted through the sludge gate, thus giving a ratio of 1.54 per cent.

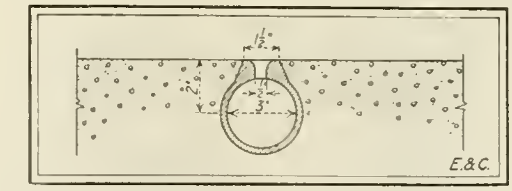

Fig. 3.—Detail of Underdrain and Orifice for Sludge Removal System, Moorestown Deferrization Plant.

Figure 2 illustrates a settling tank with perforated bottom designed by the writer for the removal of iron from ground water and erected at Moorestown, N. J. The iron deposits collecting in the bottom of the settling compartment are here removed weekly and without any interruption of service through an underdrain system similar to that at Muskogee. Essential to the successful operation of such a system of sludge removal is a high velocity through the sludge openings in the floor of the basin, and the frequent removal of the sludge, especially when this has a tendency to pack or solidify. In any one zone, also, the velocity through the orifices must be fairly uniform so as to secure a uniform removal of the sludge. When the available head for sludge removal is small, as is the case in a shallow tank, a sufficiently high velocity can be secured by reducing to a minimum the loss of head at entrance and exit. The loss of head at entrance can be reduced by a rounded orifice, such as shown in Fig. 3, which shows the rounded orifice used at the Moorestown plant, and the loss of hydrostatic head lost with the sludge water can be reduced by enlarging the sludge outlet.

## SOME DATA ON THE OPERATION OF THE PURIFICATION PLANT OF WILMINGTON, DEL.

The purification plant of Wilmington, Del., consists of preliminary filters, sedimentation basins and final filter. The water flows by gravity to the preliminary filters, of which there are 10, each 14½x100 ft., the medium being gravel, coke and sponge, through which the water passes upward. After the water has passed these filters, it is possible to treat it with liquid chlorine. The water then flows by gravity to the pumps, from whence it is delivered to the settling reservoir. The settling reservoir has a capacity of 35,000,000 gal., 91½ per cent of which is available. From the settling reservoir the water flows by gravity to the final filters. The final filters are regular English slow sand units. There are six of these units, each 364x40 ft. The water after passing these filters is treated with liquid chlorine before entering the mains. The water flows by gravity to the consumers.

The following figures on the operation of the plant are taken from the annual report of Edgar M. Hoopes, Jr., Chief Engineer of the Water Department, for the fiscal year ending June 30, 1915.

The total quantity of water delivered to the slow sand filters was 3,518,990,000 gal. (36-in. Venturi meter registration) of which 8,400,000 gal. or 0.24 per cent was consumed in washing the sand beds. The remainder of 3,510,590,000 gal. is the net amount delivered to consumers. The total quantity of water delivered from the preliminary filters was 3,551,373,390 gal., or about 40,000,000 gal. more than was actually distributed. This amount represents the difference in water stored at Porter Reservoir at the beginning and end of the year as well as leakage in the forcing main between the pumping station and reservoir.

At the slow sand, or final filters, the average rate of filtration was 4,900,000 gal. per acre per day, and the time of beds out of service for washing or raking 13.78 per cent. The average time out of service for each bed was 2.3 per cent.

The total number of gallons of water treated with liquid chlorine was 2,859,410,000 or about 84.2 per cent of the amount actually distributed to consumers. The actual time during which this treatment was applied was 308 days or 84.2 per cent of the year. For this purpose 3,842.5 lb. of chlorine were consumed—equivalent to 1,343 lb. of gas per million gallons of water treated. The total quantity of water used for absorbing this gas prior to treatment was 347,089 gal., or 1 lb. of chlorine to 750 lb. of water. A subdivision of operating expenses is given in the following table—interest on plant investment or depreciation not being included.

| Slow Sand Filtration (3,510,590,000 gal.). | Total. | Per 1,000,000 gal. |
|---|---|---|
| Salaries | $1,578 | $0.449 |
| Labor | 349 | .099 |
| Supplies | 582 | .163 |
| Light and power | 620 | .176 |
| Repairs and renewals to equipment | 297 | .084 |
| Miscellaneous | 535 | .152 |
| Total | $3,961 | $1.123 |
| Preliminary Filtration (3,551,373,390 gal). | | |
| Salaries | $1,293 | $0.364 |
| Labor | 11 | .003 |
| Supplies | 101 | .028 |
| Repairs and renewals to equipment | 31 | .008 |
| Light and power | 166 | .046 |
| Miscellaneous | 60 | .016 |
| Total | $1,661 | $0.465 |
| Laboratory (3,551,373,390 gal.) | | |
| Salaries | $1,516 | $0.426 |
| Labor | 299 | .084 |
| Supplies | 143 | .040 |
| Repairs and renewals to equipment | 6 | .002 |
| Miscellaneous | 313 | .088 |
| Total | $2,277 | $0.640 |

## ADAPTATION OF FLOUR AND FEED BLENDING MACHINE TO FEEDING COAGULANTS.

Contributed by W. T. McClenahan, Monmouth, Ill.

The original filtration plant at New Kensington, Pa., like many other plants treating water by the use of coagulants, was provided with the typical mixing tubs, mechanical stirring device and regulation orifice box. The installation contemplated the use of coagulants made up in liquid form and was satisfactory so long as lime was not the coagulant used.

When the plant was first started in December, 1912, alum and soda ash were the coagulants used. Considerable trouble was experienced at times with the "red water plague." In the spring of 1914, when Mr. Chester A. Humphreys as chemist, and the writer as superintendent, took charge of the plant it was soon determined that not only was iron causing the trouble, but that there were sufficient quantities present at most times in the Alleghany River water to give good floculation without the addition of alum. There seemed to be some variation in the chemical makeup of the iron, so that no single method of treatment would be satisfactory at all times, but usually the addition of lime alone would take out all the iron and color.

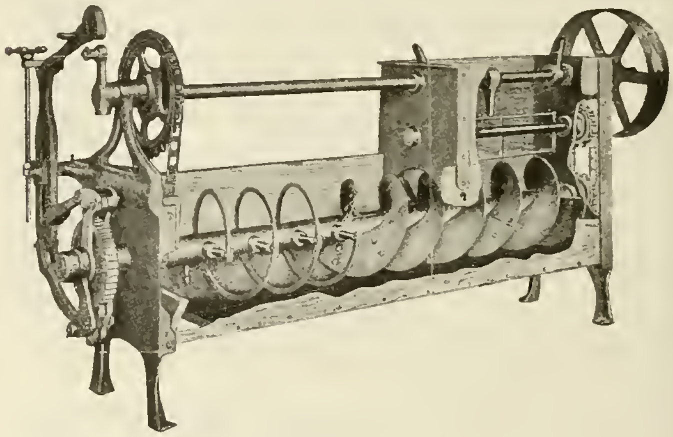

Fig. 1—Gauntt Feeder.

Attempts were first made to feed the hydrate of lime by making it up in a milk solution in the mixing tubs and regulating by an ordinary hand-operated valve instead of the regular orifice box. However, it was found difficult to keep the solution of uniform strength, even though the stirring device was kept going. Clogging pipes and control valve also gave trouble and the method of mixing a batch of the lime with water caused noxious and disagreeable fumes to arise through the room and produce irritation in the nose and throat of the operator. This method of feeding lime being altogether unsuited to our conditions, we began looking for a more satisfactory way and naturally turned to the various dry feed machines for help.

About this time Mr. Humphreys saw some flour and feed blending machines, manufactured by the F. G. Gauntt Mfg. Co., Fort Wayne, Ind., and was convinced that they could be used to feed dry lime. To substantiate his beliefs he installed one of the machines at Charleroi, Pa., for experimental work and tests. These tests were so successful that we installed two more machines at the plant at New Kensington and these have been in successful operation for over a year and a half. The writer designed and installed the equipment, including the accessories of special design.

Referring to Fig. 2 it will be noted that the installation makes use of the old water wheel and the horizontal line shaft over the top of the mixing tubs to drive the machines. A 2-in. belt pulley was bolted to the line shaft opposite the belt wheel of each machine. The machines were suspended from the ceiling of the tub room by a hanger frame not shown in the drawing. The hanger frame also furnished support for the belt wheel, short shaft and spur wheel of the bevel gear set shown at the left of the drawing.

A hopper in the storage room above discharges the lime through a tin chute into the mouth of the machine below. By means of a solid helical screw conveyor and a ribbon conveyor the chemical is moved toward the outlet end of the machine, where it drops through a galvanized iron spout into a specially designed mixing funnel, where it is thoroughly mixed with water as it enters the coagulant pipe lines. The waste water from the old water motor is used to convey the lime from the machine to the low service pump discharge not far from its entry into the settling basin.

### Detail of Parts.

**The Gauntt Machine (See Fig. 1).**—The solid helical screw conveyor on the right measures the chemical and deals it out from the bin in doses whose size is governed by the rotation of the shaft, as follows: By means of the ratchet wheel on the left on the end of shaft to which the solid helix is attached and by two sets of dogs actuated by the rocker arm system of levers, the conveyor is made to revolve in an anti-clockwise direction and to push forward a small dose of chemical to be taken up by the ribbon conveyor. The speed at which the helical conveyor is made to revolve is governed by the number of notches taken in the ratchet wheel at each movement of the rocker arm. Adjustment as to the number of notches taken is made by the hand wheel and long screw shown on the outer end of the rocker arm. The arrangement of the levers and fulcrums causes a greater or less travel of the dogs according as the end of the rocker arm is lowered or raised by the hand wheel. Further adjustment of this travel was provided for on our machines by substituting a perforated disc wheel for the crank shown in the cut at the end of the drive shaft. The crank pin could be inserted at three different places in this disc wheel so that its radius of travel and therefore the magnitude of the rocker arm movement was greater or less as the pin was moved out or in on the disc.

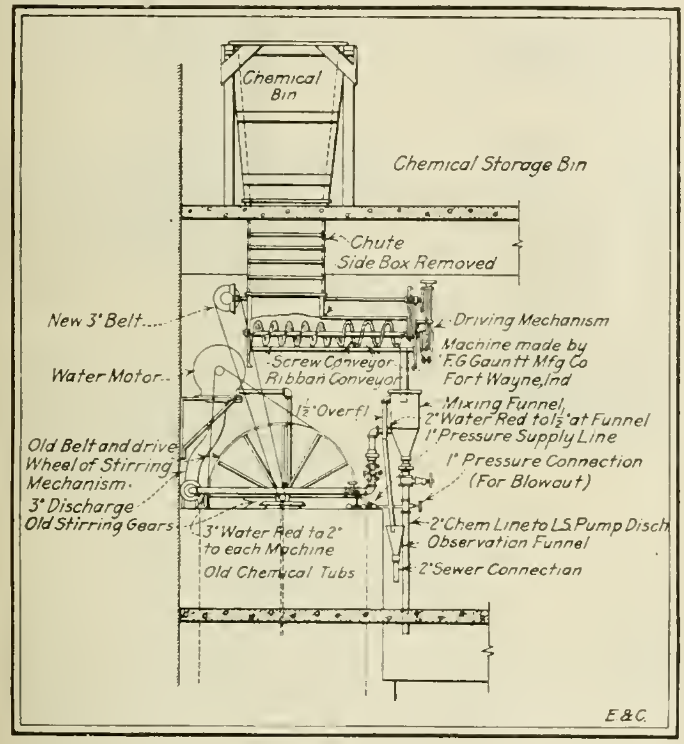

Fig. 2—Dry Chemical Feeding Installation.

The rate of feed, however, is determined not only by the number of notches taken in the ratchet wheel at each movement of the rocker arm, but is also affected by the speed of the water motor which drives the machine, so that quite a range in the rate of feed is obtainable.

The ribbon conveyor is driven much faster than the solid conveyor just described and cuts up the large dose of chemical shoved forward by the latter and delivers it to the mixing funnel in almost a continuous stream. It is made of a narrow piece of metal held out from a hollow center shaft by numerous posts and takes the form of a helical line. The shaft runs outside the shaft of the solid conveyor and is driven from the drive shaft above by a sprocket chain over the outlet.

In the mouth of the machine the cut shows two sets of agitators which keep the chemical moving toward the conveyor.

In our machine the helix was made single leaf instead of double as shown in the cut. We also had 64 teeth made in the ratchet wheel instead of 32 as ordinarily made. The effect of these changes was to reduce the capacity of the machines so that the rate of feed was much less.

**Mixing Funnels (See Fig. 3).**—The mixing funnel is made of one piece of cast iron and a lid, both given a slush coating of enamel to prevent rusting and to make them smooth inside and out. Galvanized iron funnels were tried, but they did not last.

Water from the water motor comes in through the lower opening on the side and spills over the edge of the inside ring in a thin sheet, being collected and discharged through the opening in the bottom. Chemical from the machine above drops down through the galvanized spout through the opening in the lid into the midst of the vortex formed as the water spills over the ring weir. The chemical thoroughly mixes with the water and the volume of water being quite large little trouble is experienced with the lines clogging.

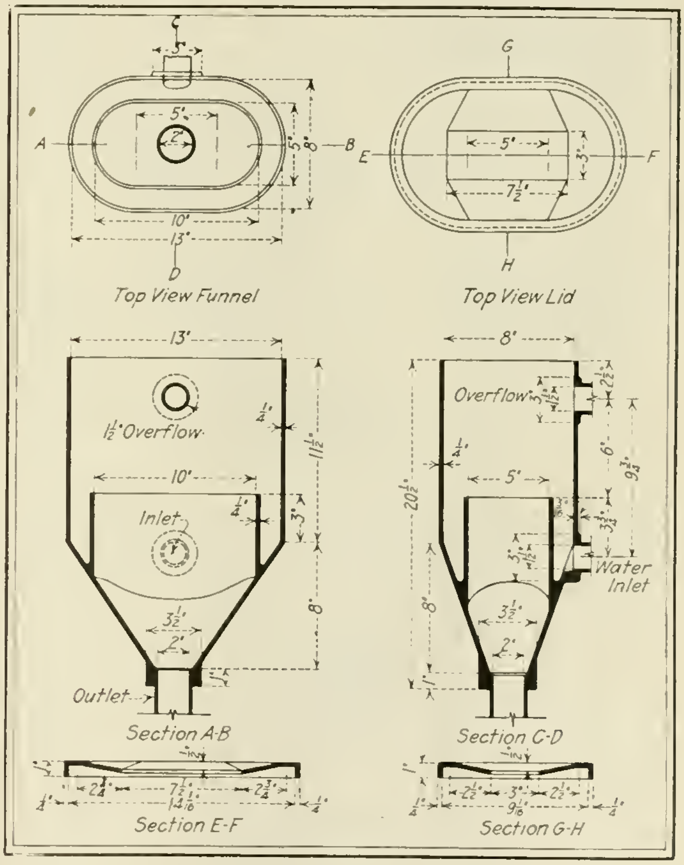

Fig. 3—Chemical Mixing Funnel and Lid.

**Water Motor and Speed Reduction.**—The water motor was placed high enough that the waste water might flow to the funnels by gravity. There is a speed reduction from 1,000 R. P. M. at the water motor to 4 R. P. M. at the drive shaft of the machine.

**Piping and Valves (See Fig. 2).**—Most of the piping arrangement is obvious, but some details are noteworthy.

A valve in the branch supply line to each machine regulates the amount of water delivered to each funnel.

A funnel is cut out by stopping the machine and closing this valve.

A ¾-in. pressure connection to one of the branches on the motor side of one of these valves furnishes extra water to either or both machines in case the waste from the water motor proves insufficient, which condition has never occurred.

Another 1-in. pressure connection was made to the coagulant lines below a valve placed just under the mixing funnel, so that the coagulant lines can be flushed out under pressure at regular intervals.

The overflow pipe from the mixing funnel discharges in the open into a small funnel which connects to the sewer.

**Hopper Bin (See Fig. 4).**—In the Charleroi installation, where lime was fed, a rectangular box 2 ft. by 3 ft. section by 4 ft. high was used with the hopper bottom extending up only half way on the sides. The box was made of untreated white pine flooring with the boards running horizontally. The chute was 7 in. square.

With this hopper trouble was continually experienced with the lime sticking and hanging to the sides of the bin, with it arching over the opening and with another peculiar phenomenon we called "piping." Undoubtedly the design of the hopper was poor in that the grain of the wood and the cracks were at right angles to the travel of the lime particles. We also thought that the slopes of the bottom of the hopper were too flat. The writer also thought that the soft untreated pine sides would have a tendency to absorb moisture and that small lime particles would therefore adhere to the sides and increase the frictional resistance. However, this point was never verified and resistance from such a cause may be insignificant.

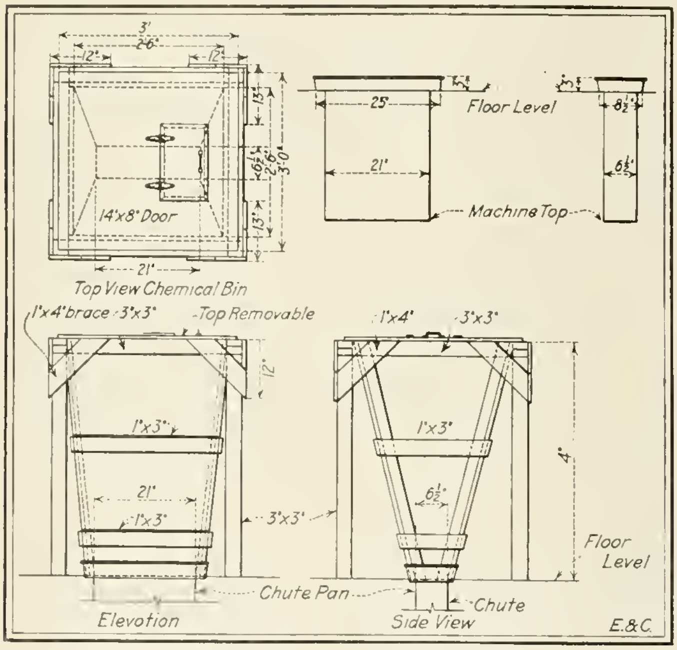

Fig. 4—Chemical Feed Bin.

The large frictional resistance of this Charleroi bin, combined with a small square opening in the bottom of the hopper seemed to cause the lime to arch over the opening and leave a large cave-like cavity at the bottom of the bin. Sometimes the hole took another form and assumed the shape of a round cylindrical opening from the bottom to the top of the lime charge. We called this phenomenon "piping," from its resemblance to a stovepipe. Either condition resulted in the machine running empty if it was not discovered in time.

The writer, to remedy the defects in the Charleroi hopper, had the boards in the side of the hopper run vertically, so that the grain of the wood and the cracks were in the direction of the travel of the lime particles. He brought the slopes clear to the top of the bin, so that they were much steeper. He made the sides of hard maple, which takes a hard, smooth finish, and shellacked the bin inside and outside to fill the pores of the wood and prevent absorption of moisture. To prevent arching and "piping" the chute was made the full size of the machine mouth, which made one dimension three times the other dimension.

In actual operation the flat sides of this opening seem to prevent the piping entirely and most of the arching. Whatever arching has occurred has developed at one end and has usually broken down before the machine ran empty. The lime shows no tendency to stick to the sides, but breaks away clean and free.

On top of the lime bin a removable white pine cover has been provided, with a small door just big enough to admit the end of a sack of lime when filling the bin. This prevents the lime dust from coming up into the face of the operator and has been much appreciated by him. A small hole cut in the cover away from the operator allows exit to the entrapped air as the sack is poured into the bin.

A two-step stair was found convenient, for the bin is too high to load easily from the floor.

The chute was made of heavy tin, enclosed in a wooden box below the floor line. Tin was thought to be smoother than galvanized iron and therefore more desirable. The top of the tin chute was flared out like the bell of a pipe and fitted over the outside of the wooden hopper above. The joint between the tin and the hopper mouth was sealed with cement to make it dust-tight. The lower end of the tin chute slips inside the mouth of the Gauntt machine.

**Remarks.**—The installation herein described has given excellent service in feeding both lime hydrate and iron sulphate. The writer believes it can be used in feeding other chemicals that do not absorb moisture readily and become caked. He has never seen it tried with powdered alum, but he believes it could be used with alum, provided care was taken to keep the alum stored in a dry place, away from the air, so that the powder would feed.

One suggestion to those who should happen to install machines like these would be to use some other drive than a belt where the pulleys are so small and especially where the belt is nearly vertical. Ours gave some trouble slipping on the pulleys.

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## INTERCEPTING DEVICE FOR FRANKFORD CREEK HIGH LEVEL SEWER, PHILADELPHIA.

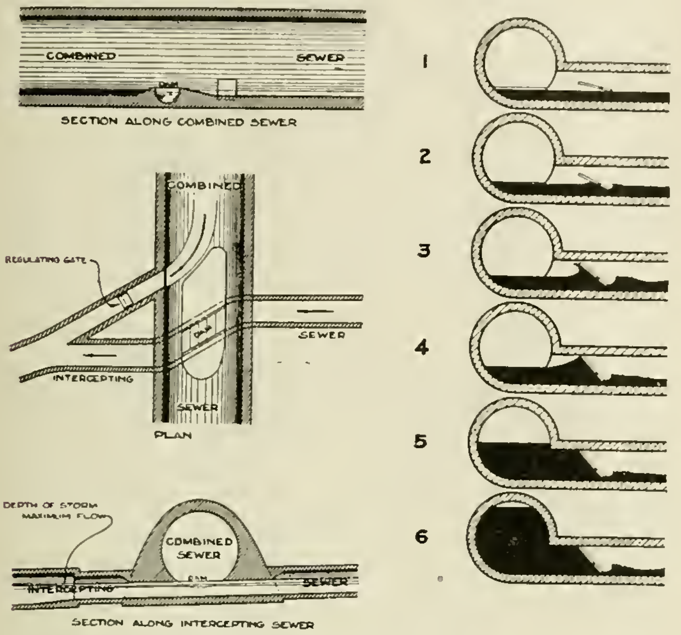
In connection with the plans for the Frankford Creek high level intercepting sewer at Philadelphia, Pa., a new design has been made for admitting sewage into the interceptor from the combined sewer. This design consists of a combination of the intercepting device used in Dresden, Germany, and a regulating gate without any float control designed by one of the engineers of the Bureau of Surveys of Philadelphia. The following description of the method is taken from a paper presented before Boston Society of Civil Engineers by W. L. Stevenson, assistant engineer in charge, Sewage Disposal Division, Philadelphia, and printed in the September Journal of the society:

The maximum hydraulic grade line in the intercepting sewer is fixed at the point of interception at or as near below as possible to the 1950 estimated "storm maximum" elevation of water surface in the combined sewer. This means that generally the intercepting sewer passes through the combined sewer. The intercepting sewers are designed so that "storm maximum flows" are at three-fourths capacity or in circular sections at two-thirds depth. The one-third air space is carried through the combined sewer, and the top of the intercepting sewer is constructed of cast iron plates, which form the crest of a dam in the invert of the combined sewer. The crest of this dam is at the elevation of "storm maximum" flow in the combined sewer, and hence serves to hold back all flows of less than that amount.

In the side of the combined sewer and upstream from the dam a rectangular opening is made to carry the dry-weather sewage flow and such portion of storm water as predetermined to the intercepting sewer.

In this rectangular conduit, between the combined sewer and the intercepting sewer, there is placed the regulating device, which consists of a structural steel rectangular leaf, supported below its center by a horizontal shaft. The natural tendency of the leaf is to rest against stops in a nearly horizontal position, due to the fact that the center of gravity of the leaf is above the point of support.

The horizontal shaft is placed at about the same elevation as the crest of the dam in the combined sewer, and consequently all flows below this elevation pass freely under the regulator into the intercepting sewer. When storm water increases the depth of flow to an elevation above the horizontal shaft, the lower part of the leaf offers resistance to the free flow and causes the water to rise in back of the gate, which increases the pressure upon the upper part and causes the gate to begin to close. The rate of closure depends upon the velocity of approach to the gate and to the height of water beyond the gate.



Arrangement of Intercepting Device.

In its closed position the upper part of the gate bears against the top of the rectangular conduit, but the lower part of the gate is designed to clear the bottom of the conduit by an amount sufficient to leave an opening beneath, so that when the combined sewer runs full, the head upon the opening will cause a discharge under the regulator equal to the average dry-weather flow. This allows a velocity in front of the gate to keep grit in the storm water moving forward, instead of settling in the approach to the gate. When the flow in the combined sewer abates to an elevation where the hydrostatic pressure on the upper part of the gate is less than upon the lower part, the natural tendency of the regulator causes it to open and the normal flows are resumed to the intercepting sewer.

## EQUALIZING TABLE FOR DELIVERY CAPACITY OF WROUGHT IRON PIPE.

It is frequently desired to know what number of pipes of a given size are equal in carrying capacity to one pipe of a larger size. At the same velocity of flow the volume delivered by two pipes of different sizes is proportional to the squares of their diameters; thus one 4-in. pipe will deliver the same volume as four 2-in. pipes. With the same head, however, the velocity is less in the smaller pipe, owing to greater proportionate friction, and the volume delivered by the larger pipe varies about as the square root of the fifth power. The accompanying table has been prepared on this basis. The table was calculated by Mr. Fred Schulder, head of the architect's service department of the United Brass Mfg. Co., Cleveland, O., and is printed in a recently issued catalog of the water works brass goods manufactured by the company.

As the actual inside diameter of wrought iron pipe in most of the sizes smaller than 2 in. is considerably more than the nominal size of the pipe, the actual inside diameters have been taken for the calculation, approximating to the 1/10 in. The delivery capacities given should therefore be quite accurate. The table follows:

| Nominal size. | Proportionate delivery capacity. |
|---|---:|
| ⅛-in. | 5 |
| ¼-in. | 10 |
| ⅜-in. | 18 |
| ½-in. | 28 |
| ¾-in. | 57 |
| 1 -in. | 100 |
| 1¼-in. | 232 |
| 1½-in. | 324 |
| 2 -in. | 566 |
| 2½-in. | 988 |
| 3 -in. | 1,558 |
| 3½-in. | 2,292 |
| 4 -in. | 3,200 |
| 4½-in. | 4,296 |
| 5 -in. | 5,591 |
| 6 -in. | 8,818 |
| 7 -in. | 12,964 |
| 8 -in. | 18,102 |
| 9 -in. | 24,300 |
| 10 -in. | 31,623 |
| ⅝-in. L. P. | 31 |

**Directions for Using Table.**—To find the size of pipe required to supply a number of smaller pipes, it is only necessary to add the proportionate capacities of all the pipes to be supplied. The pipe required will be the size having the same, or a greater capacity. For example:

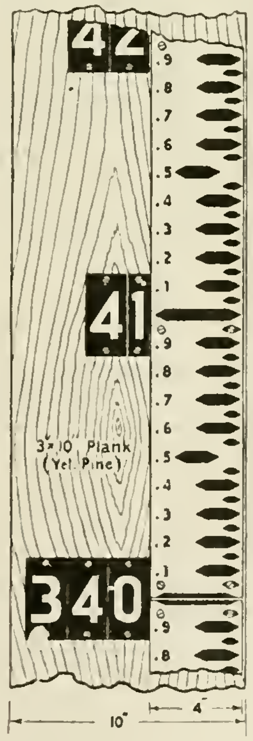
To find the size pipe required to supply five ⅜-in., four ½-in., two ¾-in., four 1-in. and one 1¼-in. pipes, add:

5 x 18 = 90
4 x 28 = 112
2 x 57 = 114
4 x 100 = 400
1 x 232 = 232
948

The size required is 2½-in., which equals 988. Had the squares of the diameter of the various pipes been taken, a pipe larger than actually required would have been indicated.

## NEW STANDARD VERTICAL STAFF GAGE OF NEW YORK STATE ENGINEERS' DEPARTMENT.

The accompanying illustration shows the new standard vertical gage staff of the New York State Engineers' Department. This staff will replace those now in use. It shows directly actual elevations above Barge Canal datum (sea level). The gage plate sections are 4 ft. long, and the gage and numerical plates are fastened to timber with No. 9, 1-in. round head brass screws. The gage was designed by G. E. Gibson, assistant engineer.



New York Standard Vertical Staff Gage.

## AN EMERGENCY GANG IN A WATER SERVICE.*

By George H. Finneran.†

The tools essential to the efficient operation of an emergency force are as follows:

Heavy wrenches for the operation of large gates. These usually are made with detachable handles. T-handles are used in some cases and crosses or four-arm handles are used in others. The latter kind allows of a more continuous movement; it allows each man to apply his force more directly and with less wasted energy than with the T-handle, where hand room is limited and the men are more crowded in their movements. More leverage can be obtained with either handle by the use of extensions in the form of short pieces of iron pipe, or hand spikes set into sockets on the handle of the wrench. Norway iron is the best material for wrenches, because of its toughness. Steel is more brittle and liable to break in cold weather. The wrench should be as short as practicable. The gate nut should be brought to a uniform distance below the street surface by means of an extension permanently attached and in place under ground. A recently made device in the shape of a long hollow steel wrench with an adjustable handle appears to do away with the necessity of these extensions. The wrench is made of square steel tubing and is long enough to reach a deeply buried gate. The handle moves up and down along the wrench column. It can be placed at a convenient height and kept in place by a pin passing through holes bored at intervals through the wrench rod. It is light and efficient.

Other wrenches lighter in make should be carried for operating the smaller size gates. It is well to have a wrench with an open socket equipped with sliding wedges. These are of much value where the stem nut is smaller than usual or where the corners of the nut have been worn smooth. Wrenches for corporation and curb cocks, hydrants, air valves, etc., also should be carried.

Monkey and stillson wrenches are required at times; also calking tools, driving and sledge hammers, crowbar, picks and shovels, a stiff broom, a hand pump, a long-handled spoon to remove dirt from gate boxes, white and red lanterns and a strong light with reflector to locate gates and gate marks at night. A good light is made of a small acetylene gas tank, such as was used to furnish gas for the headlights of automobiles before electric lighting became so common. A burner and reflector may be attached to the tank and the whole outfit suspended by bands and a handle, so that it may be carried by hand and the rays of light sent in any direction. The headlights of the auto may also be utilized to a certain extent.

A gasoline or kerosene torch, such as is used by railroad men to thaw out frogs and switches, is useful in winter to thaw out frozen gate covers and melt the ice that sometimes forms in small gate boxes which fill with mud and water.

Connection pieces to replace temporarily frozen, leaky and stopped meters are useful. A force pump to clear out stoppages, and other fittings that may be applied as first aid in time of trouble, should also be included.

Hip rubber boots should be furnished the men and they should have suitable storm clothing as protection against the weather.

A useful adjunct to the equipment is a powerful lifting jack. Frequently a heavily loaded team sinks into a soft spot in the street, caused by a leak, and it is good policy to assist in extricating it, thus minimizing the loss of time which will be included in the claim for damages that is certain to follow.

Plans should be carried on the car showing the pipe system in a condensed form, at a scale of 200 or 400 ft. to the inch. These should be in the form of blue prints and kept up to date. They are of great help to the men, especially when they answer calls in new territory or in some suburban district where they are not well acquainted with the pipe lines.

A gate finder is also useful at times, especially so in cases where tarvia and other bituminous preparations are spread upon the streets and become soft and plastic and "crawl" under the rolling motion of traffic, covering the gate boxes by a thin layer. The gate finder is a magnetized needle which is deflected towards the ground when it passes over the spot where the iron cover lies buried.

In Boston we have a more positive way of locating our gates. A distance mark is stenciled on a fence, pole or building directly opposite the gate if possible, telling the number of feet from the mark out to the gate. If it is not possible to place the mark opposite the gate, it tells the distance between the mark and a point opposite the gate. A stenciled arrow shows the direction, right or left, of the marks, that one must measure to get the opposite point. In other words, the mark gives the base and perpendicular of a right angle triangle, the apex of the triangle being the gate. Sometimes these marks are black on a white ground; other times the reverse, according to the color of the background. The object is to make them as conspicuous as possible, especially at night. When the ground is covered with snow these marks are invaluable. In squares and intersections where there are many gates within a small radius, a sign is erected on a post with the distances for all the gates tied from the one point, viz., the post. This makes unnecessary a number of marks on the corners and sides of the squares or intersections and concentrates the information at one point. The sign is not unsightly. It has gold letters on a dark blue ground and is similar in outline and general appearance to the street name signs. A measuring tape is a necessity in connection with the gate distance marks.

The automobile should be in the form of a truck with a specially designed body suitable for the carriage of men. The best arrangement is to have the seats run lengthwise with the body and use the space under the seats for the storage of wrenches, tools, etc. The body should be accessible from the rear by means of a hanging step. It should be a powerful car of not less than 40 h.p., preferably more if there are hilly sections to cover, and if the city is located where the snow falls frequently and to some depth. It should have tires of ample size to carry the maximum load. It should be equipped with demountable rims and carry an inflated spare tire. The tires should be of the best quality and be kept inflated to the limit at all times. It will be found that this will give better service and will prove more economical in the end. In fact, it will pay in every way to get a good car, even if the first cost is high, rather than to buy a cheap outfit that will fail you at the critical moment and will be in the repair shop a considerable portion of its life. It is well to have the car equipped with a warning signal similar to the fire department, viz., a bell with swinging tongue, otherwise traffic will pay no attention to your efforts to get a right of way.

In Boston we have an emergency car, with body of special design, seats running lengthwise. Exclusive of the chauffeur it can easily carry 14 men. It has a top with side curtains and is fairly comfortable in the most inclement weather. The chassis is a White, 40 h.p., built in 1911, and is still doing good work, with no prospect of our replacing it with a later model. The first 17,000 miles of the car cost us practically nothing except for oil, gasoline and tires. Since then, considering the nature of the service and the severe conditions under which the car is run, it has given very good results. Twice in five years it has been overhauled, and with the exception of a spring leaf breaking, or a wheel bearing becoming loose, or a brake band wearing, no trouble has been experienced since the last overhauling. It has traveled about 37,000 miles up to date. We have among our other cars one of similar make to our emergency car, with body suitable for emergency work and general department work combined. This car serves at times to take the place of the emergency car should anything happen to put that car out of service. It is a safe precaution to have another car in service to serve as a substitute for the emergency car, as no matter how good the car may be, or how carefully it is run, there is always the possibility of its meeting with an accident.

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*Abstract of a paper presented Sept. 15 at the Convention of New England Waterworks Association. The paper in full will appear in the Journal of the Association.

†General Foreman Water Service, Public Works Department, Boston, Mass.

The duty of the car as we use it in Boston is very severe. It is operated 24 hours a day by four different chauffeurs. It cannot choose its route, but must travel in the most direct way to the place it is summoned. The pavements may be rough or smooth, the stopping and starting frequent. Such conditions are a great strain on an automobile.

The car averages about 200 trips a month. Each trip averages 3½ miles. As the department operates 16 additional automobiles, eight of which are trucks, much business that would ordinarily be done by the emergency car is done by these trucks. Our policy is to keep the emergency car and its crew in quarters as much as possible, so that when a real occasion for its use arises it is on the spot ready for business and not two or three miles away engaged in some unimportant work that could easily wait until it can be cared for through the regular channels of business. As it is, it answers many false alarms.

The emergency gang as operated in Boston is divided into three 8-hour shifts, each in charge of a leader. The day shift consists of four men, including the leader. Each of the night shifts consists of six men, including the leader. There is besides a man on duty in the office during each of the night shifts and on Sundays and holidays. He attends the telephone and takes all messages and notifications and directs the emergency gang to the point of trouble.

Owing to the 8-hour law we cannot work the men more than six days a week. It is, therefore, necessary for each man to suspend his work one day in seven. This is so arranged that there will be but one man off on each shift each day. This practice of laying the men off one day in seven reduces the number of men available by one the greater part of the week. To offset this we were obliged to add one more man to each shift to serve as a substitute during the absence of a regular man on his night off or during his vacation. Some risk is attached to laying off the leader, as he is the most capable man and the most serious break is likely to occur the night he is off.

Most of the calls could be attended to by one or two men, but as we do not know when the big job will come it is necessary to have a sufficient number of men on hand at all times to meet it. During the day it is always possible to get assistance in handling large gates, but at night it is practically impossible. Therefore, in the event of a break in the lines of large diameter with water flowing at a great velocity through the valves it is necessary to have at least five men to close the 36-in. gates that control the same. Arrangements are made so that in the event of a very difficult shut-down, where several large gates have to be operated against a strong head, other men on duty in the stable and fire room may be called out to assist.

A device invented by the writer has proved itself capable of great service in the operation of large gates. It is incorporated in the mechanism of the automobile emergency car and consists of a universal wrench socket actuated by a worm gear, placed within a housing on the side footboard of the car in such a position that it can easily be brought over the gate manhole in the street. When the car is in position over the manhole a wrench is slipped through the socket and fits on the stem nut of the gate below. The universal wrench socket, together with a universal joint on the end of the wrench, affords flexibility in case the car is not on level ground or the wrench socket not directly over the gate stem nut. It is an easy matter, however, for the chauffeur to bring his car into the right position. The worm gear that actuates the wrench socket is driven by a horizontal shaft leading from a gear case back of the regular transmission of the auto. This gear case encloses a sliding gear clutch incorporated in, and acting directly upon, the driving shaft of the car. The clutch gear has teeth on both ends that engage with internal gears according to its position. It is operated by a lever placed upon the side of the car and easily accessible to the operator. It has three positions—one where its rear end engages with an internal gear that turns the driving shaft of the car; one where its front end engages with an internal gear that externally meshes with the pinion of the horizontal shaft that drives the worm gear, which in turn actuates the wrench socket; and a neutral position, where everything is idle. In closing gates the forward speeds of the auto are used, in opening, the reverse is used. All gears are made of chrome or nickel steel. All bearings are ball bearings, and all parts except the horizontal shaft are housed in aluminum. The housing is firmly bolted to the frame of the chassis and well braced to resist torque. The wrench used is a hollow square steel tube, terminating in a specially hardened steel socket with universal joint between socket and tube. As fast as possible gates are being equipped with indicators, showing position of valve and informing the operator when the valve is seated or entirely opened. Where indicators are not attached as yet to gates, a counter is used. It is placed on the upper end of the wrench and records the number of revolutions made by the wrench. As a means of safety in the event of the valve seating with force, or unexpectedly, a pin of known strength, placed in the universal joint of the wrench, shears off and breaks the line of power between the engine and the gate and prevents damage to either the gate or the gate operating device. The machine takes up little space and does not interfere in the least with the ordinary use of the auto.

We have used the device to some extent in ordinary maintenance work, i. e., the closing and opening of gates incidental to repairs and changes in the pipe system. We have also used it to a limited extent as an adjunct of gate inspection, running the valve down and up to observe its operation and to facilitate its movement. Fortunately, however, our opportunity to use it as a real emergency device has been limited to one occasion, a few months ago, when our 42-in. High Service main broke in Copley Square.

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## AN ENGLISH ADMISSION OF THE SUPERIORITY OF AMERICAN WATERPIPE.

It is not often that one reads in an English trade journal so frank an admission of the superiority of anything made in America, but in "The Ironmonger," June 24, 1916, Mr. Percy G. Donald not only concedes the superiority of American "tube," but scathingly arraigns British manufacturers. Mr. Donald purchased and supervised the laying of large quantities of waterpipe for war purposes in Egypt during 1915 and had unequaled opportunity to compare British and American pipe. It should be a considerable source of satisfaction to American engineers and waterworks men to read the following abstracts from Mr. Donald's article:

Probably the construction of this pipe-line in Egypt is the only occasion on which opportunity has occurred of testing under equal conditions, side by side, British, American and Canadian pipe. The inaccessibility of the sites in which the pipe was laid necessitated man-handling for the bulk of the pipe, and this, with other conditions, normal and abnormal, gave opportunity of noting results such as no other job could have given. My remarks and general experience apply more to pipe in sizes running from 3 in. to 6 in. than to the smaller sizes.

When water was pumped through, a very large proportion of the British joints leaked, but one could travel for miles along the American pipe without finding one leaking joint, and this notwithstanding the free use of red lead with the British thread, while in many cases no red lead was used at all with the American thread.

The American socket has the inside slightly beveled before the thread starts, with the result that when the pipe is knocked about the thread is not damaged. In the American pipe the socket is invariably recessed, which effectually prevents any damage, but the beveling above referred to is cheaper and quite effective.

The British pipes were sent out with the thread quite dry, both at the socket and the spigot-end, with the result that where they were not already rusted upon arrival, rust set in within a few days. The American pipes were filled in with a heavy fat mixed with black lead, which even a hot sun did not melt. The foregoing remarks explain partly why one gang of men working on British pipe could only fit 756 ft. of 6-in. pipe in one day (and that figure was a record), while the same gang working on American pipe fitted well over double the length in the same time. The rest of the explanation is in the shorter length of the British pipes and the type of thread adopted by British makers.

For 2½-in. to 6-in. pipe the British standard is eleven threads to the inch, and the American eight threads to the inch.

With the British thread cross-threading is the hardest thing in the world to avoid when fitting pipes of from 3 in. to 7 in., and by no means easy to avoid when threading them.

The British thread, whilst possibly suitable for 1-in. to 2-in. pipes, is, in fact, much too fine for large pipes. In endeavoring to fit together pipes with British thread on the Egyptian job, it was found that unless the pipes were started off dead straight the only result was to cross-thread, and thereby ruin either the thread of the pipe that was being fitted or the socket of the pipe that had already been fitted—or both.

In laying a pipe-line the static head and the friction head both have to be considered. The friction head is increased by obstructions or bends in the pipe, and when a burr such as is left on the British pipes occurs every 18 ft., the matter is serious, especially when the pumps provided are only just equal to their work. That such a defect may jeopardize a whole scheme is shown by the fact that a large section of a job in London had actually to be taken out entirely through this cause.

This is a strong indictment, but when one undertakes work such as this Egyptian pipe-line, possibly the largest of its kind, and hears British sappers and engineers, after experience with British and American pipe, cry with one voice, "Give us Yankee pipe"—one feels strongly on the point.

In the United States standardization is on a very different basis, and owing to this fact the States can produce tubes of a higher quality and greater weight at prices considerably below those of the British manufacturer, although the latter gets his labor at about half the cost the American maker pays.

The American test is much higher than ours. Every American pipemaker's list states straightforwardly what each pipe is tested to. I have failed to find this most essential information in any British list. The difference in practice between the two countries is that the Americans have one pipe for gas, water, and steam and the British three. The American tests were carried out by the National Tube Co.

The American practice calls for a greater length of thread in the socket than does the British. This is a very necessary precaution. The fact that the U. S. pipe is tested to a higher pressure than our steam pipe is worthy of note. The main point, however, is that while our works are tinkering about with three different weights to manufacture, three different stocks to carry, and a costly system of painting to differentiate the pipes, the Americans have reduced their costs of manufacture by producing one pipe only, and a pipe that is apparently better than our steam and cheaper than our gas-pipe.

American pipes are made in lengths of about 20 ft.; ours in lengths of 16 ft. to 18 ft. As the cost of making a 20-ft. pipe is about the same as that of making one of 16 ft., they get a big pull over us here.

Apart from this specialization the American manufacturer will have nothing to do with fittings. He holds that the making of fittings is a separate industry altogether, and that his time is fully and most remuneratively employed in turning out tubes at the lowest cost by scientific manufacturing processes. Again, the American manufacturer does not want orders for less than a carload (16 to 18 tons). Smaller orders are either accepted at very much higher rates or more often are referred to the nearest merchant. This practice secures low railroad rates and saves the cost of travelers and clerical staff.

Such a thing as a tube manufacturer opening stocking branches to increase his "on costs" or running a number of small works is unknown in the United States. Indeed, the first thing that is done when a number of small works are amalgamated is to scrap the lot and build one large new works to manufacture on the most modern labor-saving lines.

Apart from the labor costs in America being nearly double ours, the distance from the American works to the shipping port is three to five times that of British works. The comparisons given below are based on the huge purchase for the British Government which I had to handle in December, 1915, and which for the sake of comparison I will place as amounting to £126,000, based on American discounts. All prices are f.o.b. The British makers' figures do not take into account the charge for thread protectors, which are supplied free with all U. S. A. pipes.

DECEMBER 1915 PURCHASE.

| | U. S. A. | British combine. |
|---|---|---|
| Gas | £126,000 | £180,000 |
| Water | | 197,000 |
| Steam | | 217,248 |

MAY 1915 PURCHASE.

| | U. S. A. | British combine. |
|---|---|---|
| Gas | £ 84,144 | £161,600 |
| Water | | 180,000 |
| Steam | | 197,424 |

To what extent this state of things may be attributable to our manufacturing methods, the peculiar methods of British combines or lack of standardization, are points well worth the attention of the Board of Trade Committee that has been appointed to consider the future of the British iron, steel and engineering industries.

What better time than the present to create a proper standard, to scrap our absurd differentiations between gas, water and steam pipes, to scrap such unnecessary sizes as ⅝ in. 1¼ in., 1¾ in., and 2¼ in., to adjust our threads for the larger sizes, to leave to the fittings manufacturer the job of turning out fittings at competitive prices, and to make our profits on low costs?

Up to the present the Americans have not got into other markets owing to the differences in their threads. But what is today's position? The export of tubes to foreign countries is prohibited. This means that the greater part of the world is bound to go to America for them, and where once the U. S. thread and pipe is adopted our opportunity of regaining the market is remote, unless our price and our goods are right.

## WATER SERVICE PIPES.*

The committee began its investigations by sending to every water department in New England a request for information in regard to the materials and methods used in service-pipe construction, the troubles experienced, and other matters which appeared to the committee to be of interest in this connection. Replies were received from over 300 water departments, many of them giving complete and valuable information. In considering the information contained in the replies received, it should be borne in mind that the returns from New England included a large number of small places. The returns from outside of New England are chiefly confined to larger places.

**Materials Used for Service Pipes.**—The returns in regard to the material now used for new services may be summarized as follows:

Wrought iron or steel, 13; galvanized iron, 145; lead, 48; lead lined, 13; cement lined, 37; galvanized and lead, 14; galvanized and cement lined, 4; galvanized, lead and cement lined, 2; galvanized and lead lined, 10; iron and cement lined, 2; cement lined and lead lined, 1; cement lined and lead, 2; lead and lead lined, 4; lead and wrought iron, 3; miscellaneous, 6; total, 304.

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*From the Preliminary Report of Committee on Service Pipes submitted at the Portland, Me., Convention of the New England Water Works Association.

The use of plain wrought iron or steel is becoming rare, while nearly one-half of the places sending in reports now use galvanized wrought iron or steel exclusively; in 56 per cent of the places galvanized iron is used either exclusively or in part. In 95 places lead or lead-lined pipes are used, and cement-lined pipes in 48 places.

Of the new water works systems—those constructed within the past 10 years—the following materials have been used for services: Galvanized, 24; plain wrought iron, 1; lead, 2; cement lined, 9.

**Changes Made in Material Used.**—Many towns are using certain material for service pipes for the reason that the use of this particular material was begun when the works were installed, and, although much trouble has been experienced, no change has been made. There are, however, about 100 places where changes are reported to have been made for various reasons. The disfavor with which plain iron and steel are regarded is shown by the fact that 22 places have changed from these materials to some other, while only one place has reported as having taken up this material. Galvanized pipe, on the other hand, has lost only 17 while gaining 46. Lead and lead-lined pipes have gained 18 and 16 places respectively and lost 6 and 8. Changes to cement-lined pipes have occurred in 11 places, and changes from cement-lined pipes to some other material have occurred in 27 places.

A comparison of the number of places now using the different materials with the number of places where this material has been abandoned shows that 63 per cent of those formerly using plain iron or steel pipes have changed to some other material. Eight per cent have changed from galvanized iron; 19 per cent from lead or lead lined; and 42 per cent from cement lined.

The changes from plain and galvanized pipes are almost entirely on account of rust. The changes from lead pipes are largely on account of the possibility of lead poisoning, although in some cases it has been on account of expense or because of the bursting of the pipes under pressure. Lead-lined pipe has been abandoned on account of lead poisoning and trouble from bursting and because of the difficulty in making joints which will not corrode. Of 20 places reporting the abandonment of cement-lined pipes, 8 were on account of trouble at the joints, 6 for convenience, 2 on account of expense, 1 on account of the difficulty in getting good work, 1 because of rust, 1 because the cement broke off, 1 because of outside rust.

A large proportion of the places where the works have been in operation for a sufficient time report trouble with service pipes no matter what the material used, except in the case of cement-lined pipes. With cement-lined pipes, 54 per cent of the places reporting report little or no trouble. With galvanized pipe, 36 per cent of the places report little or no trouble, and with lead pipe 10 per cent so report. The trouble with iron and steel pipes, both plain and galvanized, appears to be through the entire length of the pipe. The trouble with lead pipes appears largely at the corporation cock. The trouble with cement-lined pipes is very largely corrosion of the outside of the pipe just inside the cellar walls, with some trouble at the lead gooseneck.

**Life of Service Pipes.**—The data in regard to length of life of a service pipe and the period that elapses before it begins to give trouble are very unsatisfactory. The averages of the figures given in the returns are as follows:

| | Years before trouble begins. | Life of pipe (years). |
|---|---|---|
| Plain iron or steel | 12 | 16 |
| Galvanized | 15 | 20 |
| Lead | 10 | 35 |
| Lead lined | 10 | 23 |
| Cement lined | 14 | 28 |

**Size of Service.**—The standard size for services is ordinarily ¾ in., but in several cases this size has been increased to 1 in. or even to 1¼ in. for the purpose, chiefly, of lengthening the life of the service. Where plain or galvanized steel or wrought-iron pipes are used, the pipes soon fill up with rust, but the service which they render is fairly satisfactory until the pipes become nearly choked, when they must be cleaned. A 1-in. pipe has about twice the area of ¾-in. pipe and will probably last at least twice as long before it will require cleaning. Where meters are not used, there is some objection to the use of large service pipes as the waste of water from leaks and from carelessness and especially the use of water through garden hose is considerably larger with the larger service. Where meters are used, this objection does not apply, and it seems to the committee that much trouble and expense might be saved, where pipes are used which are liable to corrode, if the services should be made of larger size.

The extent to which larger service pipes are used is shown in the following table, which gives the standard size reported by those making returns:

| Standard size of service (inches). | Number of places. |
|---|---|
| ⅝ | 33 |
| ½ | 16 |
| ¾ | 198 |
| 1 | 51 |
| 1¼ | 5 |
| 1½ | 2 |

**Cleaning Service Pipes.**—During the past few years great advances have been made in the methods of cleaning service pipes, and it is now possible to save large sums which have heretofore been paid for digging up the services and for renewals. The committee has not discussed the merits of the different types of cleaners, but all of them seem to have some merit. The most satisfactory in many cases, and especially with lead pipes or when goosenecks are used, is the force pump and wad of paper which permits the cleaning of the gooseneck and corporation cock as well as the straight pipe.

**Method of Paying for Services.**—Custom varies as to the method of charging for services, but in New England the general custom is for the department to pay for the service from the main to the curb cock or to the property line, the remainder being paid for by the owner. Outside of New England the custom appears to be quite different, and in the majority of places making returns the customer is obliged to pay practically all of the cost of the service from the main to the house.

The following table gives the proportion of the cost of the services paid for by the water departments in New England and in the states outside of New England:

| | Number of places | | |
|---|---|---|---|
| | New England. | Other states. | Total. |
| None | 41 | 38 | 79 |
| To curb or property line | 174 | 10 | 184 |
| Corporation | 8 | 4 | 12 |
| Corporation and curb cock | 3 | .. | 3 |
| Miscellaneous | 15 | 2 | 17 |

**Portion of Service Laid by Water Department.**—The almost universal opinion among superintendents, especially in New England, is that the water department should lay and maintain all the services from the main to the stop, and waste in the cellar whatever portion of the expense may be borne by the department. The cities and towns in which this is not now done are comparatively few, and in these places the superintendents in many cases have expressed the opinion that it would be wise for the department to take charge of the entire service.

The following table gives statistics in regard to the portion of the service which is laid by the department and the portion laid by the owners:

| | Number of places | | |
|---|---|---|---|
| | New England. | Other states. | Total. |
| None | 27 | 17 | 44 |
| To curb or property line | 94 | 24 | 118 |
| To cellar | 117 | 6 | 123 |
| Corporation | ... | 6 | 6 |
| Miscellaneous | 2 | .. | 2 |

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**Maintenance Cost of Plank and Tar Concrete Sidewalks.**—An investigation by the City Engineer of Newton, Mass., shows that an average of 3 per cent of the total area of coal tar concrete sidewalks in that city have been repaired each year during the past 7 years and that the average cost of maintenance of these sidewalks is about 2 ct. per square yard per year. The cost of maintenance of the plank sidewalks has been about 14 ct. per square yard per year.

# NEWS LETTERS.

## St. Louis Items.

McCaughey Bros. of Chicago are doing some force account work on the Vandalia R. R. in Indiana.

The appeal of St. Louis stockholders of the Alton, Jerseyville & Peoria Interurban Ry. for receivership was denied by Judge Norman L. Jones of Jerseyville Circuit Court. J. J. Cummings of Chicago and other stockholders opposed the action of the St. Louis men.

R. H. Ballard has finished his work at Mozelle, Mo., and moved his outfit to another job at Newburg. He has 25,000 yards of wagon and grader work to sublet at that point.

Forty contracts for the building of sidewalks in front of property whose owners refused to make the improvements will cost the city for advertising and other local formalities more than the material and labor. The contracts were let October 7 and in no case did the bid exceed $50. In one instance the cost was but $26.25. Before performing the work, for which special tax bills will be issued against the property improved the city is compelled to publish notices of hearings and to advertise for bids. The charge for this advertising in each case was $53.43, which was in excess of the contract price for building the walks.

A. D. Thompson Co., 1005 Jefferson building, Peoria, Ill., can use a ten-team outfit on road work near Jamesburg, Ill.

Michael Wuest, 65 years old, a Centerville Station farmer, under whose direction the major part of the Centerville Station rock road was built when he was highway commissioner, died October 6 at his home after an illness of a year. He is survived by his widow, Mrs. Mary Beatric Wuest, and six children. Michael Wuest of East St. Louis. Mrs. Susan Bunning of Omaha, Neb., August, Arthur and John Wuest, and Mrs. Stephen A. Jarvis, wife of the teller of the Illinois State Bank, East St. Louis.

Columbus S. Jones, the boss stationman, is in the market for some station work. 5656 Cates avenue, St. Louis, will catch him.

The Chicago Illinois Midland Ry. Co. is asking for bids on $3\frac{1}{2}$ miles of single track and one mile of sidetrack. Profile and specification can be seen at office of H. M. Hallock, general manager, Taylorville, Ill.

The Canal Construction Co. has 17,000 yards of slip and wheeler work in Monroe County, Ill., 15 miles from St. Louis; also 15,000 yards of short haul, wheeler and machine work near McClure, Ill., to sublet.

H. H. Ferguson of Alton, vice-president of the Illinois Terminal Railroad, denied the report that the property had been sold, and he added: "It is not for sale." The line now extends from Alton through Edwardsville to Formosa, and Ferguson said the company would go ahead and build the proposed extension to O'Fallon. The ultimate plan is to build from O'Fallon to Belleville and thence to East Carondelet, forming a belt from Alton through Edwardsville, Formosa, O'Fallon and Belleville around the east side industrial district and crossing every railroad entering St. Louis and East St. Louis from the east, northeast and southeast.

A. L. Cook, Ottawa, Kan., can use several small team outfits out his way.

P. H. Smith is finishing his work at Tipton, Kan., and will have his 14-team outfit idle the latter part of this month.

C. Haven, Crocker, Mo., was in looking for work for his 8-team outfit.

M. C. Connors of Chicago was awarded a nice piece of second track work on the Burlington R. R. He also has a steam shovel busy at Wolcottville, Ind., for the Wabash Railroad.

The Heman Construction Co. of St. Louis were awarded the contract for building an interurban electric line near Murphysboro, Ill.

A severe hailstorm that passed over Nagel's Landing, Ill., cut up all of Chas. Nagel's tents, also cut the roof of his tractor all to pieces. Nagel reports that there was nothing but ribbons left of his tents and camps after the storm.

Frank McCabe, who has been resting up in Cairo, Ill., for some time, is going to break into the contracting game again. Is looking for a track laying job. A letter addressed to 230 21st street, Cairo, Ill., will reach him.

Cameron, Joyce & Co., Keokuk, Ia., were awarded an additional mile of state aid road work at Paxton, Ill. In addition to this they have outfits at work on three miles of road work in Pike County, Ill.; eight miles in Montgomery, Ill.; $11\frac{1}{2}$ miles in Knox County, Ill. Are also doing a lot of street work in Keokuk, Ia. Also building a water line for the Santa Fe R. R. in Arizona.

Bill Dankleff is moving his outfit from Taylor Springs, Ill., to Hillsboro, Ill., onto a job that he subbed from M. C. Connors & Co., of Chicago

Keating Bros. have finished their work on the Iron Mountain R. R. at Bush, Ill. Will have 16 teams idle in a few days.

At a conference between Director of Public Utilities Hooke and representatives of steamboat and barge lines it was definitely decided to build the municipal dock on the site selected more than a year ago by a committee appointed by Mayor Kiel. This is a strip of land on the bank of the river south of North Market street. The tract is 5,200 feet long and of a width varying from 1750 to 900 feet. At the suggestion of Robert E. Lee and John Bernhard plans for the dock will be changed so as to provide for six elevators for loading and unloading freight from boats and barges. Originally only four elevators were contemplated. Director Hookes said that the elevators will be 18x18 feet, so as to lift a wagon or auto truck to and from the level of boats lying at the dock. In addition to the elevators, there will be large cranes for handling freight and cars and wagons to the dock and to and from boats. Provision will be made for forty-four openings in the face of the dock. Fourteen of these will be equipped with mechanical conveyors for moving light freight. Like facilities will be installed in other openings as business requires them. The lowest bid submitted to the Board of Public Service for the building of the dock was that of the Heman Construction Co., which proposed to carry out the plans for $188,250. The board's estimate of the cost was $200,000. The warehouses, which are to be erected after the dock is completed, will cost about $100,000.

Contractors when in want of labor or work for their outfits write Koenig's Labor Agency, 612 Walnut street, St. Louis, or 503 Delaware street, Kansas City, Mo. A. B. Koenig.

# PERSONALS.

Edwin Doepers has been appointed city engineer of Bloomington, Ind.

M. J. Graham has been appointed county engineer of Jefferson County, Texas with office at Beaumont

Louis W. Schiedemantel, of San Antonio, Tex., has been appointed construction engineer in the Indian Service. Until recently Mr. Scheidemantel was construction engineer in the Philippines for the Government.

A. W. White, heretofore office engineer of the Chicago & Eastern Illinois R. R. at Chicago, Ill., has been appointed Division Engineer with headquarters at Salem, Ill., to succeed H. G. Sparks, transferred to the operating department.

Charles H. Hurdleston, of Palestine, Tex., manager of the State Railroad of Texas, has been appointed a member of the Texas Railroad Commission. Mr. Hurdleston at one time was superintendent of the Missouri, Kansas & Texas Ry.

George A. Kyle, consulting engineer, Portland, Ore., has been appointed engineer in charge of location and construction of the railways to be built in China for the Chinese Government by the Siems-Carey Railway & Canal Co., of St. Paul, Minn.

William L. Darling, whose resignation as chief engineer of the Northern Pacific Ry. was noted briefly in our last issue, has opened an office in St. Paul, Minn., where he will engage in a consulting practice, specializing in railway engineering and construction.

Charles Peter Weeks, architect, and W. P. Day, consulting engineer, have formed the firm of Weeks & Day, for the practice of architecture and engineering, with offices at 933 Phelan Bldg., 760 Market St., San Francisco. Mr. Weeks will conduct the architectural department, transferring his offices from the Mutual Saving Bank Bldg. Engineering design and construction will be under the direction of Mr. Day, lately succeeded to the good will of the firm of Leonard & Day, consulting engineers, now dissolved, transferring his offices from the Rialto Bldg.

The following changes in the engineering staff of the Pennsylvania R. R. have been announced: S. H. Niemeyer, division engineer of the Pittsburgh Division, appointed assistant engineer of maintenance of way, in charge of roadway and track, with headquarters at Philadelphia, Pa.; I. B. Hutchinson, Jr., division engineer of the Monongahela Division, appointed division engineer of the Pittsburgh Division; C. E. Brinser, division engineer at Williamsport, succeeds Mr. Hutchinson; A. W. McClellan, division engineer of the Trenton division, succeeds Mr. Brinser; and Elmer Irving, supervisor at Lancaster, has been appointed division engineer of the Trenton Division, succeeding Mr. McClellan.

# OBITUARY.

Robert H. Boynton, for the past three years city engineer of Frankfort, Ind., died Sept. 18.

E. M. Butz, a well-known architect and engineer, died Oct. 4 at his home in Pittsburgh, Pa., aged 57 years.

Andrew J. Crawford, of New York City, one of the best-known construction engineers in the United States, died Oct. 1, at the home of his brother-in-law at Xenia, O., of a throat malady. Mr. Crawford's last position was on the construction of the concrete dam in the foothills of the Pyrenees about 150 miles from Barcelona, Spain.

# NEW CATALOGS.

**Welding and Cutting Equipment.**—Paper; 9 in. x 6 in.; 32 pp. Searchlight Co., 415 Karpen Bldg., Chicago Ill.

This booklet contains specific information on the welding and cutting of metals by the oxy-acetylene process, together with a catalog of the equipment necessary for such work.

**Pumps.**—Paper; 9 in. x 6 in.; 32 pp. Erie Pump & Equipment Co., Erie, Pa.

This catalog describes and illustrates the Class M volute centrifugal pumps. It is issued as a ready reference for prospective buyers, and as such contains all the regular information required by the purchaser. The catalog contains a considerable amount of useful data on pumping problems.

**Engineering Instruments.**—Paper; $7\frac{3}{4}$ in. x $5\frac{1}{2}$ in.; 32 pp. Geier & Bluhm, Troy, N. Y.

This is the revised edition of the catalog of the above mentioned firm. It is devoted to illustrations and descriptions of leveling instruments, including the 20-in., 18-in. and 15-in. T-levels. Geier & Bluhm also have gotten out a 12-page circular describing the additions and improvements to their regular line of engineering instruments. This circular contains descriptions and illustrations of the transit-level, the architects' level, and the architects' convertible level.

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## STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

of "Engineering and Contracting," published every Wednesday at Chicago, Ill., for October 1, 1916.

State of Illinois, County of Cook, ss.:

Before me, a notary public in and for the state and county aforesaid, personally appeared H. P. Gillette, who, having been duly sworn according to law, deposes and says that he is the business manager of "Engineering and Contracting," and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager, are:

Publisher—M. C. Clark Publishing Company, Chicago, Ill.
Editor—C. T. Murray, Chicago, Ill
Managing Editor—H. P. Gillette, Chicago, Ill.
Business Manager—H. P. Gillette, Chicago, Ill.

2. That the owners are, (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock): H. P. Gillette, Chicago, Ill.; N. M. Clark, Chicago, Ill.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other security are: (If there are none, so state.)

None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustee, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest direct or indirect in the said stock, bonds or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is: (This information is required from daily publications only.)

(Signed) H. P. GILLETTE, Business Manager.

Sworn to and subscribed before me this 27th day of September, 1916.

(Seal.) C. E. MEINDERS, Notary Public.

(My commission expires June 7, 1920.)

Excavation and Railways Monthly Issue
of
# Engineering and Contracting
Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., OCTOBER 18, 1916. Number 16.

## MOTOR TRUCKING AS A BUSINESS FOR CONTRACTORS TO ENTER.

When one contractor has found it profitable to enlarge his investment in motor trucks, year by year, until he now operates 61 trucks that do hauling by contract, the time has surely come for many a contractor to consider seriously going into trucking as a business by itself. It is true that scores of contractors have already ventured into motor trucking in and around cities, taking hauling contracts by the ton-mile, by the hour, or by the day. But perhaps it requires a spectacular success like that of Mr. Stedman Bent of Philadelphia to stimulate hundreds of other contractors to enter this field without timidity and with determination to build up a large and profitable enterprise.

Harking back to the ante-railway days, and considering also the present anti-railway days, many an old contractor will recall his early success with ten-mule "motors" hitched to freighting wagons, and will ask himself whether history is not about to repeat itself. Because capital today finds little profit in railroading, may not much of it migrate into motor trucking? May not motor trucking grow into such large proportions as even to change railroading? If so, will not large financial rewards go to the men gifted with foresight and courage enough to be among the pioneers in this new and revolutionary field of transportation?

Apparently some such questions as these were put by Mr. Bent of Philadelphia, and apparently he answered, Yes. Here is a contractor who owns 61 White trucks (5-ton), and who contracts for hauling in and about the "city of brotherly love"—at a profit that detracts nothing from the lovableness of the occupation or the city, we presume.

Motor trucking on Eighth Ave., New York City, has increased over 500 per cent in five years, according to statistics gathered by the engineers of the department of public works of Manhattan and recently published by the Garford Motor Truck Co. The horse is clearly doomed to extinction as a motive agency in city trucking. Will the motor trucks that displace the horses and wagons be owned by individuals having a relatively small amount of trucking to do, or will fleets of motor trucks be operated by contractors like Mr. Bent, who specialize in trucking? While trucking by industrial firms who operate their own motor vehicles will always exist, we look to see a progressively larger number of merchants and other city business men contract for nearly all their trucking on a ton-mile or load-mile basis. Certainly the smaller merchants and manufacturers will ultimately find it profitable to turn over all trucking to contractors who, through specializing, will not only be able to reduce operating expenses, but will be able to keep their trucks moving a larger percentage of the time.

It has long been recognized that one of the secrets of economic production in any business is to secure a "load factor" as near to 100 per cent as practicable; in other words, to reduce the idle time of the plant to a minimum. This is best accomplished through specialization. A merchant who gives his time to merchandising can neither solve the trucking problems as well as can a trucking contractor, nor can he keep his trucks as busy as can such a contractor. The saving in idle truck time will alone make a handsome profit for the trucking contractor. There are literally scores of ways of increasing the efficiency of loading, hauling and unloading goods and materials. These methods the alert contractor will learn from his own observation in part, and in larger part from reading contracting journals that give him the newest "tricks of the trade" developed by other contractors. A merchant or manufacturer can not keep abreast of the advances in his own specialty of merchandising or manufacturing, and at the same time keep abreast in another specialty such as transportation is.

Here, then, is a relatively new and growing field for contractors to enter in every city in America, namely the field of motor haulage as a special branch of the contracting business.

## THE COST OF LIGHTERAGE ACROSS THE HUDSON RIVER.

In our last Excavation and Railway Monthly issue we criticised certain estimates as to freight transportation that had been published by one of our contemporaries. Among the items criticised was 80 ct. per ton as the average cost of lightering freight across the Hudson River. The basis for this estimate was a brief submitted in 1908 by Mr. William J. Wilgus in behalf of the Amsterdam Corporation which was seeking permission from the Public Service Commission to build and operate a freight subway system.

We spoke of the 80 ct. estimate as a "guess," for it greatly exceeded certain statistics in our possession. Mr. Wilgus has kindly sent us a copy of his brief in which he quotes certain testimony and other data relating to lighterage. We wish particularly to point out two facts: First, that the 80 ct. cost of lighterage relates only to "merchandise" and not to coal and bulk freight in general; second, that it includes loading and unloading.

Mr. Wilgus cites testimony of Mr. Frank Osborne, Master Lighterman of the Pennsylvania R. R., as recorded in the report of the New York Commerce Commission for 1900. The testimony related to lighterage of "merchandise." In lightering 650,370 tons in 1898, with a marine plant investment of $400,000, the cost was as follows per ton:

| | | |
|---|---|---|
| 1. | Office and incidentals | $0.03 |
| 2. | Manning | 0.19 |
| 3. | Charter | 0.08 |
| 4. | Wharfage | 0.02 |
| 5. | Towing | 0.13 |
| 6. | Watching | 0.05 |
| 7. | Insurance | 0.01 |
| 8. | Fuel | 0.01 |
| 9. | Repairs | 0.09 |
| | Total | $0.61 |
| 10. | Loading and unloading west side of North River | 0.12 |
| 11. | Fixed charges, risks and general expense on $400,000 plant | 0.06 |
| | Total | $0.79 |

Mr. Wilgus says in his brief:

"From a reliable source the following actual costs have been obtained for lightering large tonnages. They include interest, depreciation, taxes, risks and general expenses, as well as material and labor in connection with the marine plant, but do not include items of expense in connection with shore facilities."

| | Per ton. |
|---|---|
| Heavy freight handled on power-derrick barges | $0.34 |
| Merchandise handled on hand-hoist barges, including loading, but not unloading | 0.57 |
| Freight handled in propeller barges, including loading, but not loading | 0.52 |
| Grain, not inclucing handling | 0.20 |
| Freight moved in cars on floats, not incuding loading and unloading | 0.21 |

Our contemporary ignored these figures and, although its article related to freight in general, it used an 80-ct. estimate that relates only to merchandise. Our knowledge that this 80 ct. was several times in excess of the cost of lighterage of car load lots on barges led us to condemn the 80-ct. figure as a pure guess and we still condemn it as a guess, used as the 80-ct. fiuure was used to denote an average cost of lightering freight across the Hudson. We regret having stated that Mr. Wilgus' figure of 80 ct. a ton was a guess, for used as he used it in reference to merchandise only, inclusive of loading and unloading, it was not.

It is interesting to note in this connection that Mr. Wilgus gives the following minimum estimate of lightering merchandise based on a "recent (1908) source of information":

| | Per ton. |
|---|---|
| Loading and unloading, transfer from car to pier, switching, etc.. | $0.15 |
| Water-carriage by barge and car float | 0.25 |
| Interest, taxes and depreciation and general expense on marine plant | 0.06 |
| Ditto on shore facilities on west side of North River | 0.02 |
| Total, excluding Manhattan Station expense | $0.48 |

He puts the rental of waterfront property on Manhattan at 25 ct. per ton of freight handled, plus 8 ct. for fixed charges and maintenance of piers. Unloading and handling the merchandise at the pier he puts at 30 ct. a ton, the limits of variation being 27 to 47 ct. This would make the Manhattan station expenses 63 ct. a ton, but this is not a lighterage expense.

He states that the cost of draying or trucking the freight from the Manhattan terminal to the consignee ranges from 40 ct. to $10 a ton, and probably averages 80 ct.

Mr. Wilgus estimates that a freight subway would eliminate lighterage and the trucking of nearly 25,000,000 tons annually.

## SELL DIRT AS DANLEY DID.

In ordinary times contractors have been accustomed to watch contract news items, proposal ads and the like, for "tips" that would take them by the hand and lead them to a job. But latterly, especially since the war began and railroad construction became more scarce, many a "dirt mover" has had to go out and make a contract where none existed until his arrival. To mention one large instance, William Carey, one of the most successful of railroad builders, went over to China, and not only secured a $20,000,000 canal job, but also obtained a contract calling for the construction of railways involving an expenditure of nearly $60,000,000.

While such examples are as stimulating as they are spectacular, perhaps the accomplishment of Mr. F. E. Danley, of Aurora, Ill., will better serve to indicate what a dirt moving contractor of more modest means may accomplish by the exercise of his wits. According to "The Earth Mover," Mr. Danley learned that the steel companies in South Chicago and Gary use large quantities of clay to seal their cupolas and ovens. By investigation he ascertained that a clay bed near his home town contained material that would meet the requirements of the steel companies. Freight rates permitted him to ship the clay provided he could load, haul and unload it into cars at a moderate cost.

In solving his problem of loading and hauling, he used a Western elevating grader pulled by a Rumley oil tractor (using 25 gal. of 8 ct. kerosene daily). The clay is loaded by the grader into end-dump wagons, and it is hauled to a platform where the wagons dump onto an apron that chutes the clay directly into the freight cars. In building the platform Mr. Danley selected a place where the railway track lies in a shallow cut. The platform was built out from the side of the cut.

This solution of the dirt moving problem is simple and effective, but our point here is primarily to call attention to the resourcefulness of Mr. Danley. Not only did he create this job for himself and his men, but incidentally he is uncovering a bed of good gravel. When he has stripped the clay, which he sells to the steel companies, he will have a gravel pit ready to be sold or to be worked by himself.

"Dirt" in the form of gravel or sand is marketed in huge quantities, but it would not occur to the average man that clay also may be marketed, provided it is of the right sort in the right place.

On a small scale many men earn a living through the sale of loam for garden purposes. Might not many a contractor apply Mr. Danley's methods in loading and delivering loam to cars? Might not a large and profitable business of selling dirt be thus built up by many of our readers who reside in or near cities?

Politicians are fond of saying: "The job sought me. I did not seek the job." But whatever the politician's claim to public recognition because of his modesty, certainly the business world admires the man who seeks the sort of a job that Mr. Danley sought and "landed."

## SECURING SAND BY HYDRAULIC SLUICING FROM GLACIAL DRIFT.

In regions of glacial drift deposits, large boulders are usually mixed with sand and gravel in such a manner as to make the removal of the boulders very expensive. Where the sand constitutes only 30 per cent of the deposit, as is usually the case, a serious economic problem presents itself if much sand is needed for concrete work. In the far west it has long been the practice to secure sand from glacial deposits by hydraulic sluicing, which is ordinarily the cheapest method available. In the east this method is coming into favor as rapidly as eastern engineers and contractors become familiar with the hydraulicking methods that were devised nearly half a century ago in California for placer gold mining.

In general, the effort should be made to secure a gravity supply of water for hydraulicking, and under sufficient head to undermine the banks of gravel, sand and boulders, when a large nozzle (or "monitor") plays its stream of water against the bank. But in many cases it is cheaper to pump the water for the purpose, resorting to some bank blasting to break down the gravel face.

The amount of water required depends upon the pressure to a considerable extent, but more upon the slope and roughness of the ditch or sluice that carries away the material from the gravel bank. In general, it may be said that for each cubic yard of gravel and sand moved by the water there will be required 500 to 2,000 cu. ft. of water, the ordinary average being about 1,000 cu. ft., according to Gillette's "Earthwork and Its Cost."

Where sand and gravel are to be secured for concrete, the sluices or ditches should deliver into a basin or reservoir. A brush dam can be built to retain the sand and gravel, and the overflow will carry off clay and vegetable matter. Usually two basins will be required, one being emptied of its sand and gravel while the other is being filled.

## EDITORIAL COMMENT.

Press dispatches state that Russia and Japan entered strong protests against the construction of the new Chinese railways, the contract for which has been awarded to the Siems-Carey Co., of St. Paul, Minn. Inasmuch as this $60,000,000 project is being financed by a U. S. concern, the American International Corporation of New York, it will be interesting to know on what grounds the protests are based.

Preliminary work is underway for one of the largest railroad construction jobs of the year. This is the new Pennsylvania R. R. line to Detroit and terminals in the latter city. Some reports have it that this undertaking will involve an expenditure of $40,000,000. Meanwhile the officials are giving out very little information, about the most definite being that the company "contemplates building its own track and having its own terminals in Detroit."

## WHAT IS A COLLEGE FOR?

To the Editor: Referring to the article on "What Is a College For?" I agree with your views in the main. The attitude of some of our educators toward engineering college work is due to their own training, lack of appreciation, and often actual knowledge of applied science. This is especially true of many men educated in the South where we have been slow to acknowledge the value of the applied sciences in education. These men have held to the old idea that the only true learning or culture is to be had from a study of the so-called humanities. They developed in an atmosphere which placed the trades and laborers in a class far removed from the professions and they regard engineering as a trade.

These conditions are changing rapidly in the South. Graduates of engineering colleges are taking their proper place in society and their work is so important to the growth and development of a country that they are now beginning to receive the recognition which they justly deserve.

Some 10 years ago the writer expressed through the local college paper his opinion of "What Constitutes an Engineering Education." The article was very severely criticized by a professor of Latin and Greek because the ancient languages had not been included in the curriculum. This same professor of ancient languages, now president of a state university, is devoting much of his time to boosting the study of agriculture and mechanic arts.

The engineering profession has grown until it is now beyond reason to expect a student in a short college course of 4 or 5 years to master any one of the major divisions of engineering. The demand of the times is not for engineers with a vague knowledge of many branches of engineering, but rather for men who have mastered some definite phase of the science and who possess knowledge beyond that of the average individual in his profession.

There is plenty of work for, and a bright future ahead of the engineer who develops superior skill in designing bridges, and it is not necessary or desired that this man should have special training in railway construction, drainage or steel building construction farther than these subjects bear directly on design and construction of bridges, and for such a man to spend any considerable portion of his time in college in the study of philosophy, ancient languages, history and allied subjects, is equally undesirable.

The object of college is to prepare men for useful citizenship. In the past it would seem that many of our college courses have tried to do this by offering a large number of subjects of the most general character, expecting the student to get a smattering of many things and from this conglomerate knowledge, select a foundation for his life work.

We are gradually accepting the democratic idea of education and recognizing the worth of the man of superior skill and training in any line of human endeavor. The difference between a trade and a profession is largely one of sentiment. The so-called "learned professions" number in their ranks many individuals who, if measured with the modern educational yard stick, are inferior in learning to many tradesmen. We all respect the well balanced, honest artisan in our community whether he be carpenter, blacksmith or mechanic, if he possesses skill superior to his fellows. The same respect is shown the physician or lawyer who displays superior skill to his fellows in his vocation. On the other hand the indifferent blacksmith and the slovenly physician are in the same class regardless of the fact that one belongs to the learned profession and the other is a tradesman.

The endeavor of our colleges should be to so train men that they will reach the top of their chosen profession regardless of what line of endeavor they may select for their life work. The curriculum which will accomplish this end in the largest measure much necessarily be a flexible, growing curriculum, one which shall keep abreast of the growth and development of the world. The Chinese Wall is responsible in a large measure for the present standing of that country among nations, and the college which insists on maintaining its old Greek, Latin, mathematics and philosophy curriculum will soon occupy among modern colleges a place similar to China among nations.

Yours very truly, W. N. Gladson,
Dean of the College of Engineering,
University of Arkansas.

Fayetteville, Ark., Oct. 5, 1916.

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## WHY DO NOT ALL ENGINEERING COLLEGES DEVELOP READING HABITS?

To the Editor: After reading the article, "Why Do Not All Engineering Colleges Develop Reading Habits?" published in your number of Sept. 20th, I was struck by the thought that the inquiry was more in the nature of one as to why graduates of engineering colleges do not possess the reading habit. The difference is not a mere quibble. It is quite possible that the reading habit may have been formed in a man during his college course and lost after graduation. I believe this often to be the case.

All of the influences surrounding the graduate of an engineering school or college during the first few years after his graduation are such as to discourage reading habits if he possessed them to begin with. Such influences are financial, social and industrial.

The average graduate probably receives a salary of about $50 per month. Aside from the direct objection to spending any part of such a sum on reading matter there are collateral influences all making against a tendency to read, and all resulting indirectly from the smallness of compensation. The most important of these is the kind of living quarters a man can secure for himself for the amount of money available. It is obvious that he cannot afford quarters roomy enough to permit of the housing of a library. The same holds quite as true if the man happens to be engaged on construction away from a large city and lives in a company bunk house.

So much for financial considerations. The social element enters in from the fact that the average young graduate becomes a member of an organization mostly made up of men of inferior intellects, or, at least, of inferior education, and who certainly are not readers. There is none of the stimulus of the contact of one mind with another.

The industrial reasons have several phases. The first of these is the tendency of most young engineers either from choice or necessity to shift from one location to another. In addition to the outright cost of moving a library there is the nuisance of it.

A second industrial reason is the character of the work assigned to engineering graduates in their early work. For most of them it consists either of routine drafting or of routine surveying, or of routine testing, all work that is mastered somewhere about the second year of most engineering courses. I do not contend that every graduate can be made chief engineer or manager within a month or two of his graduation. There are not enough of such places to go round, even were the men competent to fill them—which they are not. On the other hand, I do contend that employers could not only to the benefit of the men, but to their own ultimate advantage, go to some pains to make it easier for the men to get some vision of the whole of which their small task is a part. I am convinced that a great deal of the difficulty in finding men suitable for promotion within an organization results from the deadening effect of keeping men too long at routine tasks below their ultimate ability. One by-product of this deadening is the loss of the reading habit. A man doing routine work which he knows to be far below his best ability, and with no incentive to see the organization of which he is a part as a whole, either leaves such an organization, or his mental alertness adjusts itself to remaining a part of it.

It may be said that some of my points are met by the existence of public libraries. It has been my experience and observation that most of the reading done by those who do read is done by walking up and down before a shelf and selecting the volume that strikes the fancy of

the moment, then taking that volume to a chair and light with both of which the reader is familiar. It requires a decidedly cold-blooded, fanatical yearning for information to rouse a man to the point of knowing just what he wants to read, then of going to the uncongenial surroundings of a public library and getting it. Doubtless the one man in a thousand destined to fame will overcome all the obstacles, but this is an inquiry not into the influences surrounding an Edison, but into those surrounding you and me.
Sincerely,
Chester B. Lewis.

Ann Arbor, Mich., Sept. 26, 1916.

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To the Editor: Your editorial, raising a question as to the lack of reading habits among engineers, and your implied shifting of this responsibility to the engineering schools arouses me to something of a protest. I believe you have answered the question in the paragraph where you state that engineers are after all more like other men than they have been willing to concede. "They are not, as a rule, sufficiently studious of their problems." What class of men are? The point where the radical wrong exists in the mental training of engineering students begins long before they come to the schools of engineering. Reading habits are more likely to be formed in early youth than after the period in which students are in the high school. I believe, however, that you do well to call attention to this matter, and I hope it may result in arousing engineering teachers to the amazing lack of general or specific reading on the part of engineering students. I personally believe that the main reason for the lack of a higher professional sense among engineers, and their inability to co-operate on important professional policies, is due entirely to an absence of broad understanding and sympathies which must follow a neglect of wide reading and lack of interest in an affiliation with professional societies.

I am interested to know of the work being done by Professor Bozell and heartily agree in commending it and urging its application early in the engineering course. I am painfully aware, however, that very few of the teachers that we are able to secure in the engineering schools, under present industrial conditions, are themselves wide readers or appreciative of the value of wide reading. One has but to examine hastily the papers presented to the Society for the Promotion of Engineering Education to note that teachers of wide reputation are consistently presenting evidence of lack of familiarity with much that is appearing in the current technical journals. How then should the blind lead the blind? Your editorial, instead of striking me as involving an unnecessary question, rather impresses me as a voice raised in the wilderness enforcing a warning and proclaiming the way. I hope some one may present this very interesting problem at the next meeting of the Society for the Promotion of Engineering Education.

With regard to your second editorial answering Woodrow Wilson's article, "What Is a College For?" I agree with you most heartily in the aim of this editorial, which is a plea for a better understanding of the purpose of the engineering college and a closer knowledge of what it has actually accomplished. As you, yourself, say, however, you and Mr. Wilson have identical aims, but you advocate widely variant means. For the position held by Mr. Wilson, I believe engineering educators have been largely responsible. Surely you have not forgotten what was rather common among the schools of engineering when you and I were students, and that is, an emphasis on the "practical" which was not only detrimental to the student, but was entirely misleading to the teachers of the old-fashioned college or school of arts. When engineers themselves smile at agricultural engineering, and when engineering educators have tried to include every thing under the term Civil Engineering, we should not be too critical of the classical and philosophic scholar who takes us at our word, smiles with us, and confirms our judgment with his own prejudices.

After all, a keynote to your editorial lies in the statement that for progress a man must work, and that men really work only when driven by ambition. I believe also that this ambition can be aroused in the normal man only when there is a "goal in sight."

Finally, I believe that you are doing an excellent service to the engineering profession in discussing questions of this sort that lie at the very foundation of its continued existence as a profession.

Very sincerely yours,
E. J. McCaustland,
Dean and Director, School of Engineering, University of Missouri.
Columbia, Mo., Sept. 29, 1916.

## A NEW BOOK ON ROCK EXCAVATION.

Twelve years ago "Rock Excavation," by Halbert P. Gillette, was published. It was the first American treatise on this broad subject. During the last ten years a very large amount of valuable information on rock excavation has appeared in the various engineering journals and particularly in the columns of Engineering and Contracting. Mr. Gillette has not only "skimmed the cream" of all this information for his new book—"Handbook of Rock Excavation Methods and Cost"—but he has added a great many useful data from his own experience as an engineer and contractor.

The first rock book by Mr. Gillette contained chapters on tunneling, but the present book relates entirely to open-cut work. Even the chapters on "chamber blasting" and "subaqueous excavation" may be regarded as open-cut excavation. The author states in his preface that he has in preparation a book on tunnels and shafts. By eliminating all matter on underground work the author has been able to produce a treatise on rock excavation that leaves no branch of open-cut drilling and blasting incomplete. In its 840 pages of 500 words to the page the reader will find more usable information on rock excavation than was ever gathered together before in one volume.

The book contains 18 chapters, whose titles are as follows: Rocks and Their Properties; Methods and Cost of Hand Drilling; Drill Bits; Shape, Sharpening and Tempering; Machine Drills and Their Use; Cost of Machine Drilling; Steam, Compressed Air and Other Power Plants; Cable Drills, Well Drills, Augers and Cost Data; Core Drills and Cost Data; Explosives; Charging and Firing; Methods of Blasting; Loading and Transporting Rock; Quarrying Dimension Stone; Open Cut Excavation in Rubble Quarries, Pits and Mines; Railroad Rock Excavation and Boulder Blasting; Canal Excavation; Trench Work; Subaqueous Rock Excavation.

The book is profusely illustrated with drawings and photographs. It has a flexible binding and is of handbook size, which, as the author states, makes it a convenient book for the contractor or engineer to use in his every-day work in the field or office or on the train. The price of the book is $5, and it is published by the Clark Book Co., 27 William St., New York City.

## COMPARISON OF BIN AND PLACE MEASUREMENTS OF DREDGED MATERIALS.

During the period Nov. 17, 1914, to March 1, 1915, the U. S. seagoing hydraulic dredge Col. P. S. Michie was engaged in dredging inside channels in Humboldt Bay, Eureka, Cal. Due to the nature of the work it was possible to make accurate surveys and obtain a correct place measurement of the material dredged. The following results of a comparison of bin measurement and place measurement are given in Professional Memoirs for September-October, 1916:

Finished Weld.

| Shoals dredged. | Cubic yards of bin measurement. | Cubic yards of place measurement. | Kind of material dredged. |
|---|---|---|---|
| In front of Eureka.... | 133,360 | 121,875 | Fine silt in upper end; sand, gravel and clay in lower end. |
| Samoa Shoal ......... | 83,847 | 56,664 | Coarse sand and clam shells. |
| Buhne Point .......... | 19,232 | 21,381 | Very fine sand and some silt. |
| Beacon No. 9.......... | 21,228 | 28,600 | Silt, fine hard clay and beds of river gravel. |
| | 257,667 | 228,520 | |

It will be noted that where coarse, heavy material (such as sand, gravel and clam shells) was dredged the place measurement was less than the bin measurement as might be expected, but where fine, hard sand and silt was dredged the place measurement ran over the bin measurements, showing that considerable yardage is gained by agitation.

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## MATERIAL YARDS ON RAILROAD CONSTRUCTION WORK.

The proper location and layout of material yards on railroad construction are matters of no small importance. Expensive delays to the track-laying forces often are caused by improperly planned and operated material yards. Very little has been printed on this subject, and consequently a paper, prepared by R. L. Morrison, professor of highway engineering at the Agricultural and Mechanical College of Texas for presentation before a Civil Engineers' Club at the College, should prove of interest. The matter in Mr. Morrison's paper, aside from the expression of a few elementary principles, is based largely upon personal experience and observation. The paper practically in full follows:

As soon as construction begins the material yard should be carefully planned and laid out. The location of any yard is, of course, an individual problem to be governed largely by circumstances, but a few general rules can be given which will apply to practically all cases. These rules may be listed as "Don'ts":

1. Don't unload material from the main line. This is perhaps the most important of all the rules and the one most frequently disregarded. To avoid thus unloading, an apparently large expenditure for temporary tracks would be justified, for the use of the main line as a storage track is bound to cause trouble, and lots of it. The reason is obvious—the material cars are always in the way of passing work-trains, and, on the other hand, the loading gangs are continually being delayed by these trains coming along and moving their cars. I remember one instance where a large steam shovel was getting out rock for riprap, the rock being hauled about 3 miles. A gang with a locomotive crane was loading bridge steel, which had been piled along the main line. Every time a train load of rock passed, the crane and bridge cars had to be switched onto a siding and left there while the rock train ran down and unloaded. The train and the loading gang were delayed about a half hour every time the rock train made a trip, and the steam shovel was often delayed when the loading gang could not get out of the way quickly enough. To put in a switch and lay a temporary track is a small item of expense compared to the cost of working under such conditions, yet similar situations arise time and again. Very often this is because the laying of a temporary track would appear on the expense report as rather a large item, while the continued drain due to delays is so spread out that it is not apparent in the engineer's reports, although in the aggregate it amounts to much more.

2. Never unload cars on a wye track or on an operated siding.

3. Never unload material into a borrow pit or from a high fill. This not only increases the cost of reloading, but in the unloading, serious damage to the material is apt to result. It may be noted that whenever possible the unloading of material should be under the direction of someone who will also be responsible for checking and reloading it.

Of course in the construction of mountain roads it is sometimes impossible to observe the rules stated above, but in level country an economical material yard can easily be planned and quickly and cheaply carried out.

The general plan of the yard must be made to suit the locality. The number of tracks and their length will necessarily depend both upon the amount of material to be handled and the yard limitations as to size and shape. It is convenient to have material tracks "open at both ends," but if spur tracks must be used, as is generally the case, the switch should be at the end of the spur opposite in direction to the road which is being built. Thus, if the road is being extended westward, the switch should be at the east end of the spur. Then the material cars are always ahead of the engine, which is the arrangement necessary in track laying. A bumper should be placed at the end of each spur as much time may be lost if a car is shoved off the end of the track. A cribbing made of 6 or 8 ties and filled with earth can be built in a few minutes and serves the purpose very well.

There should be a slight down grade from the end of the spur toward the switch, and a considerable expense for grading to secure this will be amply repaid, as a large number of cars can be handled by a small loading gang without the assistance of an engine. If the grade happens to slope the other way, an engine may be needed every time a car is moved.

The track itself can be laid very quickly. Two bolts to a joint are sufficient and only enough ties need be used to keep the rails from being bent. About 12 ties to a rail will generally be sufficient and very little surfacing is required.

The proper distribution of the various kinds of material in the yard is the next question to be considered, as all the care exercised in getting the tracks just right will be wasted unless good judgment be used in the placing of the material, especially that which goes into the track.

The largest single item will be the crossties, and in fact the space occupied by the ties is generally much more than that needed for all the rest of the material put together. If the yard consists of several tracks then a number of them may be used only for ties, but if there is only one spur then the best place for the ties is at the end of the track furthest from the switch. Plenty of room should be reserved for all the ties that may be in the yard at any one time. Most roads have specifications for piling ties at the mills which may well be followed in the material yards if there is room. These specifications differ with different roads, but the object desired in any case is the proper seasoning of the ties. A common way of piling them is crib fashion with one layer parallel to the track and the next one at right angles to it.

There should be about 1 in. of space between each two ties, and the two end ties should be set on edge while the intermediate ties are laid flat. This allows the circulation of air about the ties. The piles should not be built higher than a man can reach while standing on the ground, as the difficulty and time required for piling increase very fast if the piles get too high. For protection from rain the top layer of ties should be laid close together, with an extra tie under one edge to give the roof a pitch. Not more than two, or at most, three ties should be in contact with the ground for these are liable to decay if the piles remain long on moist ground. If possible there should be at least $2\frac{1}{2}$ ft. of clear space about each pile, to aid the circulation of air and also to facilitate handling and inspection. All dead leaves or other inflammable material should be removed from about the tie piles.

Every carload of rails sent to the front should include the necessary angle bars, bolts, nutlocks, spikes, etc., and the rails and fastenings should be stored with this idea in view. The rails should be piled at the opposite end of the spur from the switch, or next to the ties if they are on the same track. Cross-ties make a good foundation for the rail piles; there are generally plenty of them at hand, and, as a rule, they are not badly damaged by this use.

One method of making a foundation is to place three or four rails perpendicular to the tracks, supporting each rail upon ties laid lengthwise. This requires the fewest ties, but with this arrangement they have a tendency to turn over and let the rails slide off. A better foundation is secured by laying the ties perpendicular to the rails, as they are in the track. This takes more ties, but that is not a serious objection. Enough care should be used in smoothing off the ground to keep the ties from being broken. The rails should be piled parallel to the track, except for the three supporting rails between each two layers. Camp, in "Notes on Track," mentions an instance in which every other layer of rails was at right angles to the track, but it is hard to believe that any one but a lunatic would use such a system.

If 30-ft. skid rails are used, four men can handle rails fairly well, but if short skids are used, more men will be needed for loading. On the other hand, the larger gang with the short skids will work faster because the piles are closer to the track. Probably the small gang and long skids is the more economical method. About a foot of the web and flange at one end of each skid rail should be cut away and the ball of the rail bent over so that it can be hung in the stake pockets on the cars. This simple arrangement keeps the skids securely in place and at the same time obviates the necessity of lifting each rail over the projecting ends of the skids as it is taken from the car. The skids should be kept well greased, but not by the too common method of taking oily waste from the car journals, giving the skid rails a few rubs with it, and then putting it back in the journal-box.

The short rails should be in a pile by themselves on the switch side of the other rail piles, and on one side of the pile the ends of the rails should be in an even line, leaving all the difference in length at the other side. When this is done, a man can take a 6 or 8-ft. stick with notches cut at each foot and by walking along one side of the pile can check the lengths of the rails at any time. If this simple rule is disregarded it is practically impossible to check the rails after they are in the pile.

The frogs and other switch material should be piled next to the rails, and enough time and space should be used to keep the right-hand and left-hand frogs, as well as those of different types and numbers, piled separately. When a certain frog is needed it should never be necessary to take it from the bottom of a pile.

The angle bars should come next after the switch material and can be conveniently piled up crib fashion so as to be easily checked over at any time.

When tie plates are used it is often convenient to pile them near the switch material and angle bars. They can be kept off the ground by a rough flooring of ties. The joint tie plates should be kept separate from the intermediate plates when they are of a different design. Tie plates come wired together in bunches, but so many of the wires break in unloading that it is practically impossible to pile them so that they can be accurately checked in the piles without complete rehandling.

Spikes and bolts are very difficult to handle without breaking the kegs. To reduce the breakage to a minimum, a platform should be built about half as high as a car floor and the kegs unloaded onto this. Such a platform can be easily made by cribbing up ties with a layer of ties over the cribbing for a floor. This platform should be just below the angle bars. It should be borne in mind that these kegs, like everything else in the yard, may have to be checked over from time to time and so should be piled in even rows, with the same number of kegs in each row, and the spikes and bolts should be carefully separated. If there are different sizes of spikes and bolts these different sizes should also be kept separate and each keg should be set down with the labeled end up so that it will never be necessary to turn a keg over to see what it contains. Anyone who has ever spent a few hours turning over 200-lb. bolt kegs can readily appreciate the desirability of this precaution. Nutlocks come in boxes and can be piled with the spikes and bolts. In case there is a probability of much rain or snow, the platform should be covered with a rough shed of some kind. There is generally material for cattle guards, road crossings, forms, etc., which can be temporarily used for this purpose without being seriously injured.

The lumber for small structures, and other miscellaneous material can be piled between the keg platform and the switch, as this distance should be from 200 to 400 ft. if possible.

If there is a great deal of bridge material, or material for large buildings, it should be stored on a different spur from that occupied by the track material, because these different classes of material are apt to be handled at the same time by different loading gangs and nothing should be allowed to delay the forwarding of the track material.

Now that the yard is all arranged, we shall see how the system works out. Going from the end of the spur down grade to the switch we have first (considering only track material) the place for the ties, then the rails, then the frogs and other switch material, then the angle bars and tie plates, and finally the spikes, bolts and nutlocks. Suppose the first consignment of material is six carloads of rails. The cars will be pushed in on the spur until the one first out is just opposite the rail pile nearest the switch. Suppose that there are only three piles of long rails on each side of the track. Then when the first three cars are unloaded they are very easily dropped down the track toward the switch and the three loaded cars are dropped down opposite the rail piles. With the assistance of the slight grade one man with a pinch bar can move a car load of rails as fast as he can walk and there is a very slight delay to the loading gang while shifting cars. Other material is handled in the same manner and all that is necessary is to see that the cars are spotted in the right place when they are first set in on the spur.

The real advantage of the system is shown when material is being loaded to send to the front. The man in charge of the yard should have a copy of the alignment notes of the track under construction and should know every night where the end of track is. With this information he can make up his trains and send out material to fit the track where it is to be used.

The first thing for him to do is to curve the rails to fit each curve in the line, including just the right number of short rails to keep the joints properly spaced. For this work a rail curving machine is used which is operated by a long lever turned capstan-like by ten or twelve men. As the lever is turned the machine travels along the rail, which is curved as the machine passes over it. This is a slow, expensive process and horse-power sometimes has been substituted. The machine was securely anchored and the rails were drawn through it by a horse, a block and tackle being used in the operation. Only three men were needed, including the driver, and the process was found to be cheaper and quicker than the usual method. Horsepower was also tried for loading the rails, but was not successful. In curving rails the mistake of curving them to the right for curves to the left, and vice-versa, should be avoided, as it is very inconvenient to turn them end for end.

When everything is ready for the track laying to begin a number of empty cars are set in on the spur and pushed up to the end, with the car first out opposite the rail piles as in unloading. Assume that 80 rails are loaded on the first car. Then if track laying begins at Sta. 0 + 00 this load will reach about to Sta. 13 + 20. If Sta. 6 + 60 is the P. C. of a curve, then forty rails curved to the proper degree must be put on the car first and then forty straight rails, as the latter must be unloaded first at the front. The man in charge of the loading must figure out to exactly what station each carload of rails will reach and load accordingly, figuring backwards each time, because the first rails put on the car will be the last ones taken off and put in the track.

As each car is loaded with the proper rails it is dropped down opposite the angle bars and two of these are put on for each rail. If there are no switches or tie plates to go on, the next stop is the keg platform where the proper number of spikes, bolts and nutlocks are added to the load. Everything is now on the car to be used between the stations covered by that load, and the car is dropped down to the switch to be taken out by the work train. If more than one car is taken out at a time, then the whole train, as well as the separate cars, must be loaded backwards; for the last car loaded in any train will be the first one unloaded at the front. Switches and tie plates will be sent out as needed and it is often convenient to send out cattle guards, etc., with the loads destined for the stations where the cattle guards go, though these are usually put in after the track is all finished.

Suppose enough cars have been loaded to keep the track layers busy for half a day. Before 7 a. m. the work train takes the loaded cars out of the yard so that they will be at the front in time to begin work. The train is kept busy while the track gang is at work, but during the noon hour it runs back to the yard, takes out a fresh batch of loads and sets the empties in on the spur. This operation is repeated at night, or early in the morning, and in this way one train does all the necessary switching, both in the yard and at the front, without the slightest delay to either gang. It is only the grade of the material track and the proper placing of the material that have made this efficient operation possible.

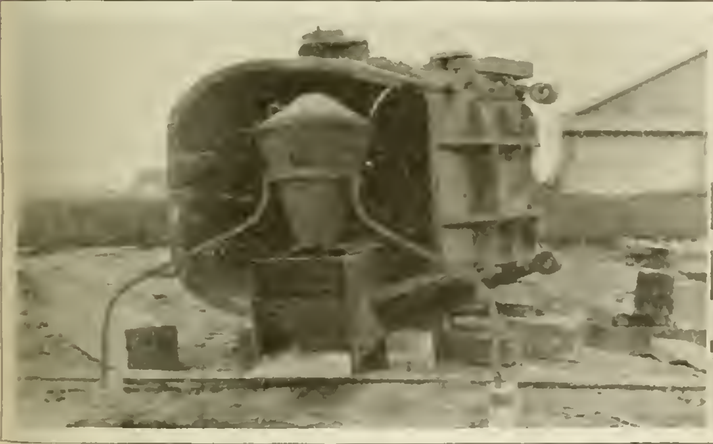
Nothing has been said yet about forwarding the ties. These are sometimes distributed from wagons, some distance ahead of the steel gang, otherwise a car of ties is sent out with each car of rails.

Of course it is the track material that must be forwarded with the greatest speed and regularity, and there is not much to be said about the handling of other things. A locomotive crane is always useful about a large yard, and it is practically indispensable where bridge steel is to be handled. It can also be used to advantage in loading rails and ties.

The methods outlined above apply, of course, principally to cases where a track-laying machine is not used.

## WELDING A DREDGE DIPPER.

A difficult welding operation on a dredge dipper was carried out recently by P. E. Rosselle of the Florida East Coast Ry. The weld was made for the dredge Grampus. The fracture in the dipper extended across the entire mouthpiece and as the extra dipper was out of commission it was necessary to make the repairs as quickly as possible so as not to delay the dredging. The weld was made without removing the mouthpiece, which necessitated working in very close quarters.



Thermit Appliance in Position for Welding.

Finished Weld.

The weld was made by the Thermit process. The fracture was first cut out with oxy-acetylene gas, leaving a space about 1 in. wide. This was done in order that the thermit would have a free flow and the parts to be welded would be brought to the melting point. The pattern was made of beeswax, 3 lb. of that material being used for this purpose. The weld box was made of ¼-in. steel. The molding material consisted of equal parts of fire clay, clean, sharp sand and crushed fire brick. The fire brick was crushed in a large pan of 1/16 in. sheet steel made to fit the bottom die of the steam hammers. The Goldschmidt Thermit Co.'s gasoline heater was used, and while the preheating was going on the crucible was set in place and charged with the exception of the ignition powder. Seventy-five pounds of railroad thermit was used for the weld. After the weld was made it was left over night to cool. The pouring gates and risers were cut off with acetylene.

This is the third thermit weld that has been made in the dipper; the first two fractures were 16 in. and 8 in. The dredge Grampus is working in 30 ft. of water at the ocean-going ferry and steamship docks at Key West, Fla., and as the bottom is an almost solid mass of coral rock formation, and the walls of the docks are of reinforced concrete, it is necessary to dig without the aid of blasting or crushing. The dipper is handled by a 90-ton hoisting chain, which has to be removed about every 2½ or 3 months.

## THAWING FROZEN GRAVEL.

Marked reduction in the cost of thawing frozen gravel in the Klondike District has been brought about by the use of hot water instead of steam. In an article in the Sibley Journal of Engineering for September Dr. Henry M. Payne states that during the season of 1915, by the employment of hot water and other improvements, the amount thawed per thawing point was increased 265 per cent; the time required to drive the points was decreased 50 per cent; the average net thawing period was decreased 50 per cent; the fuel consumption per unit thawed was decreased 65 per cent; and the number of points used per unit area (and consequent labor-saving in driving and pulling) was 70 per cent.

During the past four years a systematic study of the thawing problem has been conducted by Dr. Payne, and the whole process has been reduced to a scientific basis.

The actual temperatures, specific heats and specific gravities of the materials to be thawed have been definitely determined and several interesting physical charactesistics discovered, as, e. g., it was found that after reaching frost line the temperature drops within the next few inches to the mean temperature of the mass, depending solely on the nature of the material, and not on its depth or on water level.

The steam points, instead of being driven in rectangular arrangement, are staggered in triangular lay-out, thereby reducing the theoretical unthawed segment between the thawed cylinders of ground, or the correspondingly necessary overlap to completely thaw the area.

Experiments were carried on with hot water as a thawing medium instead of steam, the points being driven at varying distances and depths, and left for various periods and then withdrawn, and excavations made to ascertain their efficiency.

The great loss from condensation of steam was immediately corrected by this method, although the quantity of water required is 3.6 times as much as for steam at the same pressure, the boilers being supplied by injectors and the pipe line being connected with the blow-off pipe.

The next steps were: The substitution of an Ingersoll-Rand drill bit point for the ordinary one on the steam point; the design and construction of a movable anvil to fit over the steam pipe at convenient driving height above the ground, eliminating the moving and climbing of ladders at each point while driving: the use of three-way connections on steam lines; and of standard pipe lengths and train-line couplings in place of rubber hose.

Eventually the thawing point was driven to bedrock at one driving, and thawing started from the bottom up, instead of the reverse, as had always formerly been the case.

## HINTS FOR TRUCKING CONTRACTORS.

Many appliances and devices are used on motor trucks or in connection with them to expedite the handling of loads. These devices fall roughly under three heads: (1) Those that assist loading; (2) those that increase carrying, and (3) those that expedite unloading. The truck owner or prospective owner by observing what others in the same line of business have done can determine whether or not he can use similar devices in his own work. On a succeeding page sketches are shown of 24 devices or appliances. The illustrations are reproduced from a booklet, "Devices that Make for Motor Truck Efficiency," which is reprinted from "Motor Trucks of America," published by the B. F. Goodrich Co., Akron, O. The text of the article also has been taken from the above mentioned publication.

Figure 1 shows a demountable body suspended from chains ready to load. The Curtis Publishing Co. uses the device for hauling mail sacks from its plant to the railroad station. The bodies cost $165 each, and by their employment in connection with four trucks the company made a gain of 14 tons a day in haulage.

Figure 2 shows a device used in a Los Angeles lumber yard. While the truck is out delivering a hand cart is pushed round the yard and the next order is assembled upon it. The hand cart is then run under a traveling crane and the load is hoisted from the truck by chains which are fastened to two iron bars. The load is then elevated so that the truck can readily pass under it, and when this is done the load is released and the driver is ready to start.

The nest or sectional bookcase body is shown in Fig. 3. This is really a skeleton for use inside the regular body of the truck. The nest body is divided into divisions, each one capable of receiving a uniform bin or section. These sections are loaded at different parts of the store and are then placed in the nest which is then ready to be rolled onto the body of the truck when it backs up for its load.

A further modification of the demountable body idea is found in the use of individual trunks or bins (Fig. 4). These trunks are made of fibre and are packed according to the route throughout the store and sent to the delivering room. Fig. 5 shows the telpherage system or overhead track used for handling these hampers. Fig. 6 shows the escalators used in many department stores for bulky freight.

Figure 7 shows a type of hand truck capable of elevating the load and thus expediting the handling of heavy material. A power driven industrial truck is shown in Fig. 8. These have a carrying capacity up to 2 tons and are capable of negotiating the abrupt grades often met with in moving materials at docks or terminals. On level floors they are used to pull long trains of hand trucks hitched together.

A roller gravity conveyor is shown in Fig. 9. This is used for loading small and uniform units upon trucks where the nest body or trunk system is not applicable. The gravity conveyor is made long enough so that it reaches from the shipping dock to a point just behind the driver's seat, and when the forward end of the truck has been packed the conveyor is withdrawn a corresponding distance.

Figure 10 shows a power winch used for loading very heavy and rough materials. This is usually situated near the rear of the chasses and is operated by the motor with a suitable reduction of gears. A long cable is used in connection by means of which any object of a size approximating the capacity of truck can be hauled bodily into it. The winch also is of use in extricating trucks when mired. The portable crane (Fig. 11) is another loading device, separate from the truck, used in lifting heavy material.

Figure 12 shows an appliance used for loading a truck from a pile lying on the ground. This device has the advantage of being portable and can be set up without much trouble. A bin unloader is shown in Fig. 13, and a side unloader for handling coal or broken stone from cars is shown in Fig. 14.

Figure 15 illustrates a type of body devised by J. E. Mitchell of Galveston for loading bales of cotton on a motor truck. The special feature of this body consists of the two side rails of 12-in. board which extend the length of the truck. As these rails are left a foot from the ground it is possible to load bales on them from hand trucks without lifting the cotton. The bales are up-ended on this rail and are further supported by the body proper, the sides of which slope like a blunted triangle. It is not necessary to rope on the bales.

Figure 16 shows a trailer and Fig. 17 illustrates a tractor hauling a 41-ton load. The tractor semi-trailer principle is illustrated in Fig. 18. Fig 19 shows a loaded 4-wheel drive truck climbing steps and Fig 20 is a sketch of a 4-wheel drive tractor.

An arrangement for elevating the load before dumping is shown in Fig. 21. This is accomplished by means of a power hoist located midway on the chassis, which is driven by the motor operated with a leverage on front of beam which hoists the load bodily in the air and at such an angle that no further dipping is required to cause it to dump. This is of special use to dealers in coal.

Figure 22 shows a sideway dump body mounted on a chassis. A further development of this dump is to divide the body lengthwise into two compartments which permits dumping half the load to the left and half to the right. For such uses, for instance, as delivering coal into sidewalk holes an arrangement has been devised as shown in Fig. 23. The body is built with a gravity pitch and hopper bottom and is elevated with four corners by four standards, which are operated by the motor. When the chute is in place the body empties itself at the rate just suited to the rather limited sidewalk hole. For unloading heavy objects that cannot be dumped a crane is mounted on the truck as indicated in Fig. 24. This crane is particularly useful for unloading heavy and bulky objects which could not be managed except by a large gang of men. Heavy sewer pipe and iron castings come under this head, also large blocks of marble that have to be handled and set down with much care.

In connection with terminal delays one of the best suggestions that has yet been made is the following: A type of standard body is made which will fit any 3 to 5-ton chassis. These bodies are of uniform size and uniform value and are interchangeable. The terminal companies suspend these bodies from chain-falls, and when a truck arrives equipped with one of these standard bodies, with a load that would naturally take a considerable time or at any rate suffer a delay in the loading, that truck is permitted to leave its loaded body at the terminal and take back an empty standard body in place of it.

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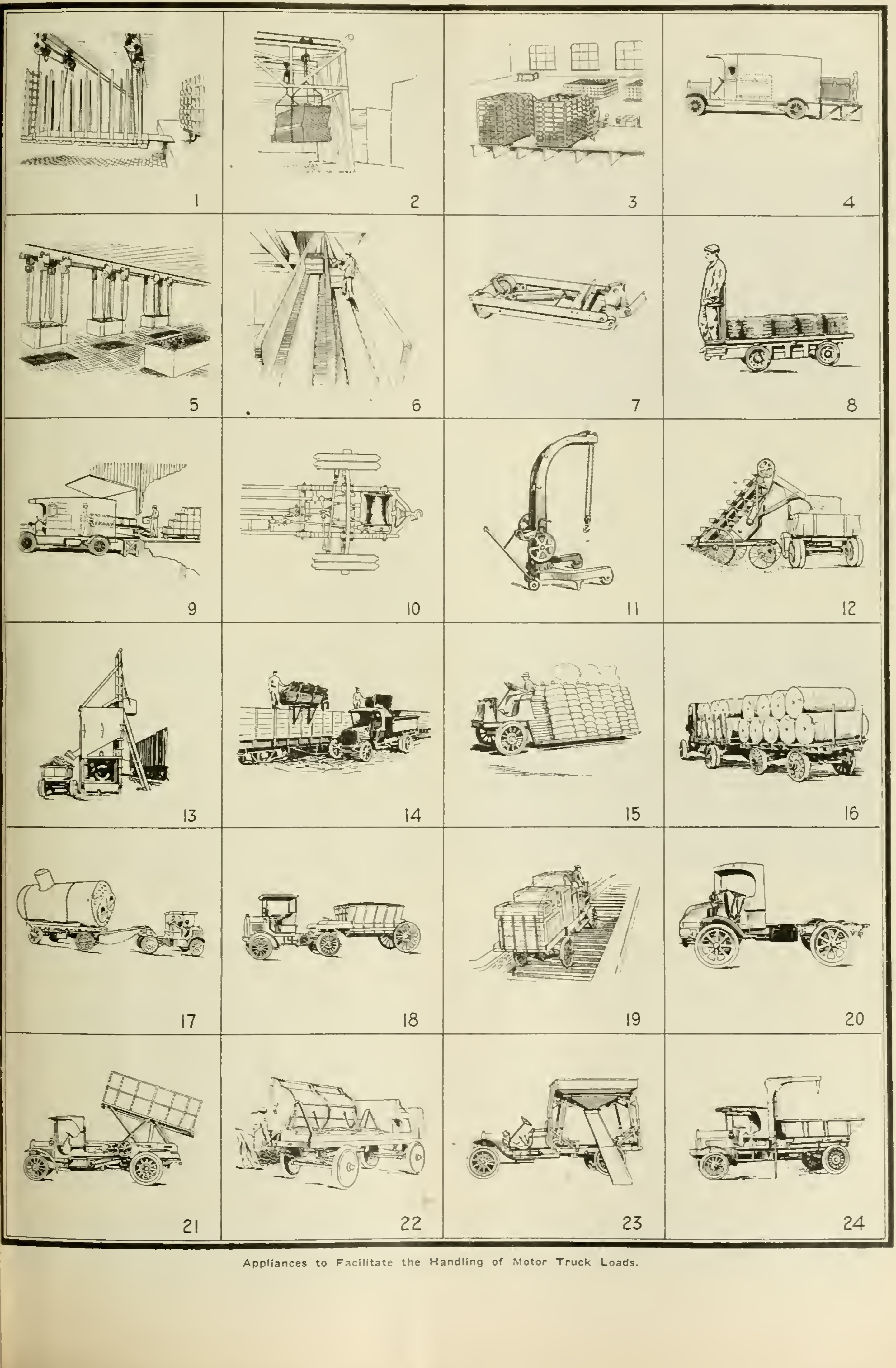
**Water Works and Purification Plants Statistics.**—According to the recently issued report "General Statistics of Cities, 1915," of the U. S. Census Bureau, of the 204 cities having more than 30,000 inhabitants in the fiscal year 1914-15, 155 or 76 per cent, owned their water supply systems. Seventy-three of these cities were operating purification plants in that year, and of this number 61 had either built or improved and enlarged their plants since 1903. During this same period there has been throughout the country a remarkable decrease in the death rate due to typhoid fever. Although this decrease has taken place in both urban and rural localities, it is noteworthy that in most of the large cities which have recently built or improved and enlarged their purification plants the decline has been greater—in some cases very much greater—than the average decline elsewhere. For example in Cleveland the typhoid death rate fell from 111 per 100,000 population in 1903 to 8.1 in 1914; in Philadelphia, from 72.3 to 7.6; in Pittsburgh, from 132.7 to 15; in Cincinnati, from 42.2 to 6.2; in Chicago, from 32.5 to 6.6; in St. Louis, from 52.6 to 12; in Washington, D. C., from 48.5 to 11.9; in Minneapolis, from 41.1 to 12.5; and in New York City, from 17.1 to 6.3.



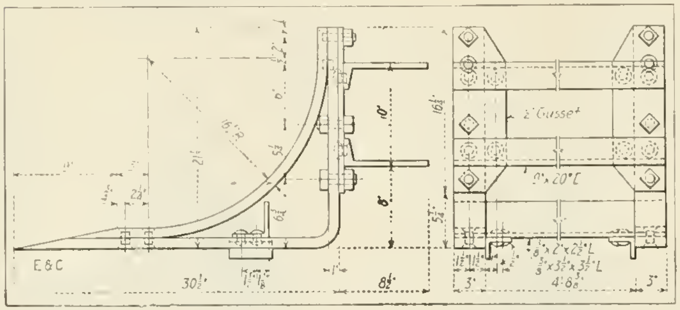
Appliances to Facilitate the Handling of Motor Truck Loads.

## AN ECONOMICAL DEVICE FOR SPREADING ROCK OR GRAVEL BALLAST.

Contributed by Clifford A. Elliott, Cost Engineer, Maintenance of Way Department, Pacific Electric Railway Co., Los Angeles, Cal.

The Pacific Railway Co. in Southern California operates 1,000 miles of electric interurban lines, radiating in all directions from Los Angeles, some lines extending 65 to 70 miles in one direction. If a ballast plow were maintained in service it would cause the work to be carried on disadvantageously, as transportation of such equipment through large cities, from one line to another, is not always permissible on account of restrictive ordinances. Consequently, to meet with economic measures and have standard means for expeditious performance of the work, the ballast shoe shown by the drawing has been designed. It is fabricated in the company's shops, 1-in. steel being used in its construction, as steel of lesser thickness will not satisfactorily stand up under the strain of the load.

The ballast shoes when placed on the rails permit a work motor to push the front wheels of the car trucks up onto the treadway, as shown. Three standard length ties are then placed one on top of the other; one rides upon the rails and the other two are affixed on extending arms made a part of the shoe, as shown. Thus the ties form the desired barrier for spreading the ballast. Hicks' standard center dump ballast cars have proceeded and distributed the rock; then same motor and empty cars return and spread the ballast, thereby economizing on work train service and avoiding tie-ups to the usual frequent service operated on electric lines. This device is superior to a method sometimes adopted by other roads of taking a work motor and one car, locking the car wheels and placing a barrier of ties in front and shoving car over the rails. This practice almost invariably results in flattened wheels, due to some extent to the finer rock or gravel accumulating on rails. With use of ballast shoes this is impossible.



Device for Spreading Ballast for Electric Railway

Each shoe weighs approximately 85 lb. and is very cheap to provide. It is fair to estimate that the shops of any company can make the shoes for $18 or $20 a pair, when the price of steel is normal. Their weight makes them easy to handle; therefore they can be transferred very readily from one point to another on the line, or exchanged between divisions. Another point of importance is the guiding wing to secure the shoe to the rail and eliminate chance of derailment.

This tool has, also, proven itself invaluable and indispensable as an aid to economical maintenance where the Pacific Electric Railway Co. has a considerable mileage in tracks contiguous to the Pacific Ocean. The majority of such trackage is constructed through beds of ocean sand, and during brisk incoming gales from the ocean the fine sand drifts extensively, burying the tracks to such extent that traffic is frequently disrupted. Naturaly, prompt removal of the sand is essential. Hand methods are slow, costly, and tedious for this purpose; therefore the ballast shoes are utilized in the same manner as in spreading ballast. This method of removing sand will accomplish in five hours what it would take 500 laborers with shovels to do in 10 hours.

## COST DATA ON HYDRAULICKING.

There is a wide range in the cost of hydraulic mining. In a recently issued bulletin of the U. S. Bureau of Mines it is stated that the cost may range from 2½ ct. per cu. yd. in California under exceptionally favorable circumstances to 12 ct. or even 20 ct. at Atlin, B. C., and to 25 ct. or more in Alaska, according to the conditions of operation, and where frozen gravel is encountered and where it is necessary to elevate the gravel, costs frequently exceed 60 ct. per cubic yard. The Bulletin gives the following data on work of this character. The first figures are for a hydraulic mine in Northern California.

The season commenced in November, 1899, and ended the last of July, 1900. During this time, 655,657 miners' inches (an inch equals 1,728 cu. ft. in 24 hours) of water were used for piping, and for sweeping the bedrock at the end of the season. From actual surveys, this amount of water washed down 1,251,399 cu. yd. of material, consisting of pay gravel lying on the bedrock, and varying in thickness from a few inches to 8 ft., and practically barren top material, consisting of mountain slide, carrying considerable broken rock, clay and soil. The banks varied in height from 50 to 130 ft., the average height being 63 ft. The grade of the sluices was 7 in. to 12 ft., the boxes being paved with block riffles 12 in. deep. Long bedrock cuts extended from the heads of the sluices to within a few feet of the banks, and were kept practically to grade as the work advanced. At first, electric drills were used on this work, but as it was found that heavy blasting shattered the rock too much, and caused slips, these drills were abandoned and hand drilling was substituted. The total cost was made up as follows:

| | Total cost. | Cost per cu. yd. |
|---|---|---|
| Care of ditch, reservoir and siphon: Labor, $2,670.99; supplies, $115.55 | $2,786.54 | $0.00223 |
| Washing (piping) | 2,401.05 | .00192 |
| Drilling in bedrock cuts: Hand drilling, $1,050.91; electric, $269.62 | 1,320.53 | .00105 |
| Timbering bedrock cuts | 157.39 | .00012 |
| Electric lighting | 598.62 | .00047 |
| Sluice building and repairing: Labor, $1,045.70; supplies, $35.50 | 1,081.20 | .00086 |
| Blacksmithing | 644.02 | .00051 |
| Cleaning up | 968.79 | .00077 |
| Moving pipes and giants | 898.85 | .00071 |
| Breaking rocks and clay | 6,124.91 | .00490 |
| Clearing ground for piping (cutting brush) | 158.37 | .00012 |
| General expenses, watching sluices and odd jobs | 3,088.69 | .00250 |
| Supplies used in mine | 3,015.37 | .00241 |
| Taxes, office expenses, surveying, salaries | 4,267.31 | .00341 |
| | $27,511.64 | $0.02198 |

The best known hydraulic mine in California, and the largest now operating in the world, is La Grange mine in Trinity County. The operating company now has a water system of 29 miles of main ditch, flume, tunnel, and siphon, 7 miles of 30-in. water-pipe line, and 14 miles of auxiliary ditch not now in use. This is supplied with all necessary reservoirs and connections for bringing the water to the face of the pit, and with the dam at the lower lake represents an outlay of approximately $700,000. Twenty-eight men, including the boarding-house force, are employed at the mine.

The method of operating is as follows: Water is brought from the mine reservoirs in two 30-in. pipe lines and discharged against the gravel bank through giants under a head of 600 ft. Either two 8-in. or one 8-in. and two 6-in. nozzles are used at one time. These combinations require 4,000 to 4,200 miner's inches of water, and they usually empty the mine reservoirs in six hours. The water is then shut off from the pipes and the reservoirs are allowed to fill, requiring generally four hours when the full head of water is in the ditch; during this time the pipe men drill and blast the large bowlders and hard pieces of cement rock in the pit.

Bowlders of 1 ton and 2 tons' weight at times pass through the sluice, though such large bowlders are generally blasted in order to save water. The cemented gravel is disintegrated usually before it leaves the pit, and little or none is found on the dump. At the usual rate of operation, the pipes wash down and send to the sluice 1,000 cu. yd. of material per hour. The sluice box is 6 ft. wide by 5 ft. deep and is lined with 40-lb. steel rails set transversely 5 in. apart on the bottom and longitudinally on the side and held in place by lugs and bolts

Quicksilver is sprinkled in the upper part of the sluice every few days. The sluice is 2,400 ft. long. The great length of sluice is necessary to carry the tailings to the edge of the dump. At 1,300 ft. is branches into two parts in order to distribute the debris over the width of Oregon Gulch. Each year it is necessary to add about 50 ft. to the lower end of each branch. The amount added to the upper end varies with the slope of the bedrock and the movement of the gravel mass.

Working costs vary for different seasons from 2.8 to 3.5 ct. per yard, the percentage of cost being distributed approximately as follows:

| Item. | Per cent. |
|---|---|
| Maintaining ditch | 18 |
| Washing, gravel piping | 9 |
| Sluice maintenance | 25 |
| Breaking bowlders | 9 |
| Pipe lines and giants | 7½ |
| Roads and buildings | 3½ |
| Clean-ups | 1 |
| Administration | 8½ |
| Taxes | 3 |
| Teaming | 5 |
| Boarding house | 8 |
| Various | 2½ |

The following data, including average operating costs, regard hydraulic mining at Atlin, B. C., for the seasons 1910 to 1913:

| | Pit 1. | Pit 2. |
|---|---|---|
| Possible running time, days per season | 184 | 180 |
| Actual running time, days per season | 154 | 141 |
| Cubic yards worked per season | 283,300 | 178,586 |
| Cubic yards per day per season | 1,540 | 992 |
| Cubic yards per day for time running | 1,840 | 1,266 |
| Miners' inches[*] used per day | 4,500 | 4,250 |
| Yards per inch per day of running time | .41 | .30 |
| Average depth of ground, feet | 60½ | 16½ |
| Average cost per cubic yards, cents.[†] | | |
| | Pit 1. | Pit 2. |
| Labor | 7.34 | 13.29 |
| Powder | 1.40 | 1.96 |
| General operations | 2.18 | 3.03 |
| Ditch maintenance | .22 | .35 |
| General expense | .44 | .70 |
| Royalties, rental, etc | .49 | .64 |
| Total | 12.07 | 20.01 |

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[*] Miner's inch = 1,728 cu. ft. in 24 hours.

[†] Boarding house included in labor. "General operations" includes supplies, teamsters, blacksmiths and other operating expense not directly chargeable to either pit. "General expense" includes traveling, offices, etc.

Costs of working gravel banks with water under pressure and elevating the material with hydraulic elevators will vary greatly in different localities. The following data concern hydraulic mining at the River Bend mine.

The River Bend mine is on the Klamath River, Siskiyou County, Cal. The water is obtained from two sources; one ditch supplies the water for the giant, the other for the elevators. The supply system includes 11 miles of ditches and 1½ miles of flume.

There are two Joshua Hendy giants with 3½-in. nozzles, which consume about 525 cu. ft. per minute, working at an effective head of 90 to 100 ft. A Campbell elevator having a 10½-in. throat and using approximately 560 cu. ft. of water per minute under an effective head of 325 ft. raises the material 46 ft. vertically. The elevator is set in a sump 10 ft. deep and at an inclination of 70°, the height of the gravel bank being 30 ft.

The following table is made from daily averages throughout the season of 1912-13. The working costs do not include administration charges.

| | |
|---|---|
| Cubic yards of gravel washed per day | 417 |
| Cubic feet of water used per minute for giants | 525 |
| Cubic feet of water used per minute for elevator | 560 |
| Cubic feet of gravel lifted per minute | 7.81 |
| Cubic yards of gravel washed per miner's inch (giant) water | 1.19 |
| Grade of sluice, inches in 12 feet | 7 |
| Operating cost per cubic yard, not including administration, cents | 8 |

At the Logan mine, near Waldo, Ore., with 40 cu. ft. of water a second, 15,000 to 30,000 cu. yd. of gravel is washed per month. Four giants are used, two in the pit and two on the tailings dump. A 20-in. hydraulic elevator with two lifts elevates the material 49 ft. The gravel is easily washed, there are no large bowlders, and the operating expenses are said to be only 3⅞ ct. per cubic yard. under exceedingly favorable conditions.

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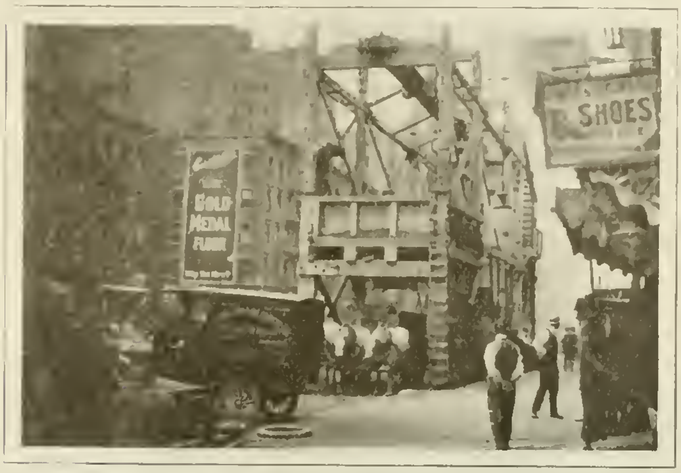
Figures compiled by the U. S. Office of Public Roads show an expenditure in the country for roads and bridges in 1915 of $282,000,000, an increase of 250 per cent over the amount spent for similar purposes in 1914.

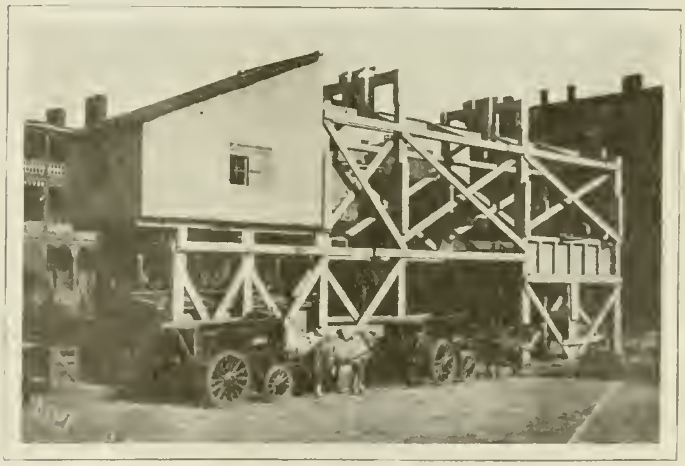
## TELPHER SYSTEM FOR DISPOSING OF EXCAVATED MATERIAL.

The United States Realty & Improvement Co., New York City, is using an interesting type of telpher system for handling excavated material from its subway construction contracts. The accompanying halftones show the plants installed at 28th St. and 7th Ave. and 13th St. and 7th Ave., New York City.

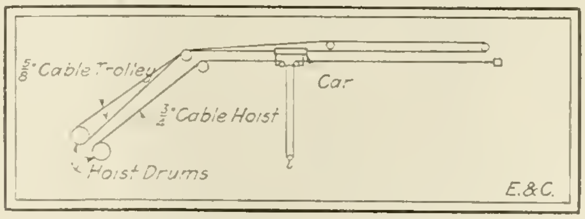


Station at 28th St. and 7th Ave., New York City.

The power for hoisting and trolleying is performed by a 60-H.P. 250-volt direct current motor. A Lidgerwood 2-drum hoist is used for hoisting and trolleying. The car is a home-made affair, composed of four standard cast iron wheels 8-in. in diameter, which run on two 18-in. I-beams. These wheels support two standard cast iron sheaves, 16-in. in diameter, through which the hoisting cable runs. The cables are arranged as shown in the sketch. Steel buckets and skips are used for handling material, the former holding about 1 yd., the latter 2 yd. of material. C. H. Stengel, 702 Flatiron Bldg., New York City, is Chief Engineer of the United States Realty & Improvement Co.



Station at 13th St. and 7th Ave., New York City.



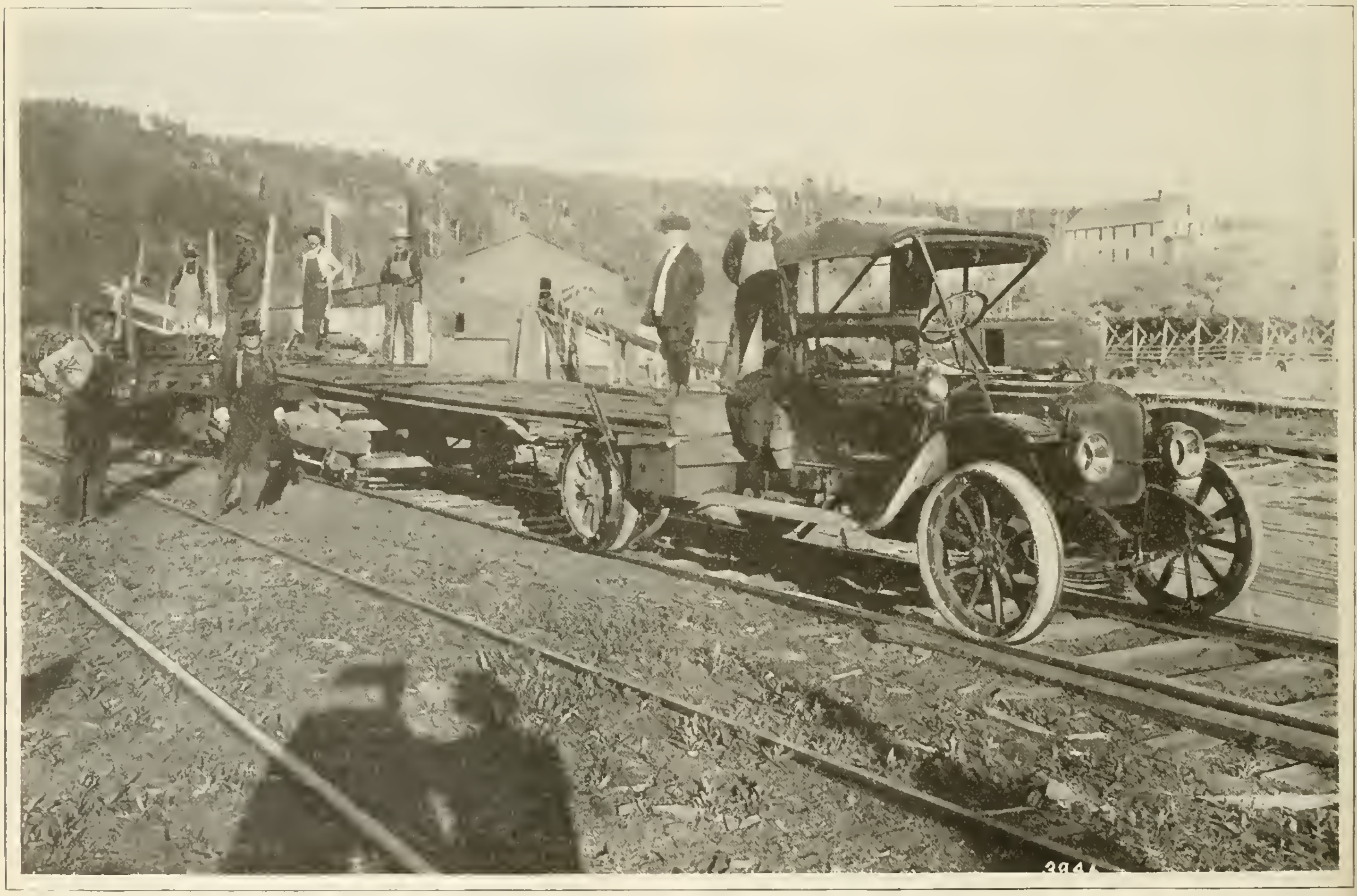
Arrangement of Cables.

## SALVAGING RAILS WITH MOTOR TRUCKS.

Motor trucks equipped with steel flanged wheels for operating on rails have made it possible and practical for railroads and construction companies to salvage rails on abandoned spur lines and in construction camps where heretofore the cost of reclaiming the rails by other methods would not have warranted the work.

The Chicago, Burlington & Quincy R. R. decided to salvage the rails on the abandoned McLaughlin lumber and tie road connecting the station at Nahant, Mont., on the Burlington system in the Black Hills of Montana with the forests 35 miles to the west and the contract for the job was awarded to the Black Hills Transfer Co. of Nahant.

The McLaughlin line had been abandoned several years ago on account of the timber being exhausted and the enforcement of the Forest Reserve Act, and when the transfer company tackled the job it was confronted with many obstacles. A locomotive could not be used to haul the rails because the forest reserve laws required oil burning locomotives and the only ones available were wood burners. The track had not been kept in repair and the cost of putting it in shape to permit the use of a heavy locomotive would have been prohibitive. Another objectionable feature to the use of a locomotive was the rank growth of long and tough grass over the rails which in some places had grown to a height of 18 in., weaving a network over the track that completely obstructed it from view.



Motor Truck Equipped With Steel Frange Wheels Salvaging Rails for C., B. & Q. R. R.

After working on several schemes and later finding them impracticable, the contractors decided to test out a White $1\frac{1}{2}$-2-ton motor truck. An order was placed with the White Co. in Cleveland for a standard $1\frac{1}{2}$-2-ton truck, which was shipped to the Burlington railroad shops at Havelock, Neb. Here it was equipped with a set of steel wheels with flanges for operating on rails, re-shipped to Nahant, Mont., and put to work.

In the first month the truck was in service it covered about 3,300 miles, averaging 108 miles a day and by the use of a flat car as a trailer, was able to haul 12 tons of rails into Nahant each trip. The truck made two round trips a day, climbing several grades as steep as 7 per cent on second and third gear and registering an economy record of better than 10 miles to a gallon of gasoline. After depositing its load at Nahant the truck covered the 27 miles to the forests on fourth speed.

## COST OF DREDGING IN 1914 AND 1915 WITH U. S. DREDGE MICHIE.

The U. S. seagoing hydraulic dredge Col. P. S. Michie was completed in December, 1912, at a cost of $378,198. The first work of the dredge was at Coos Bay. In the Professional Memoirs for September-October, 1916, the following cost figures are given on the operation of this dredge in 1914 and 1915.

The dredge arrived at Coos Bay Jan. 20, 1914, ready for work at that place.

The weather was so stormy during the winter months that little dredging was possible on the bar. The Michie continued operations on the bar whenever weather conditions permitted until May 29, 1914, when, while lying at anchor in the harbor, she was disabled by being rammed by a steamer.

The Michie was temporarily repaired on Coos Bay and then proceeded to Portland, Ore., for permanent repairs, not returning to Coos Bay until July 3, when she operated up to the 15th and then was laid up until Oct. 6, due to a lack of funds to operate the dredge. Due to the continued stormy weather and rough condition of the bar the dredge was kept in commission only to Oct. 24, 1914, when she was recalled to Astoria, Ore., to undergo trials to determine the efficiency of the machinery and such alterations as might be necessary, it having been reported that the original draghead was too large and that the dredge lacked boiler power.

The dredge was operated only 8 hours per day the first few months, but later was operated from 12 to 14 hours per day, the condition of the bar permitting. Thirty men were employed to operate the dredge this one shift.

The following table gives the amount of work done on Coos Bay the first season (1914) and its approximate cost.

The figures are taken from the ship's records and do not include any overhead expense of the Portland office or the cost of the repairs and alterations made to the dredge at the close of the season.

| Month, 1914. | Cu. yds. dredged. | Days dredge in commission. | Parts of days worked. | Average amount dredged per day. | Maximum amount dredged per day. | Total expense. |
|---|---|---|---|---|---|---|
| January | 4,719 | 9 | 2 | 2,360 | 4,552 | $3,835.30 |
| February | 10,308 | 28 | 6 | 1,718 | 4,094 | 3,442.44 |
| March | 14,890 | 31 | 8 | 1,861 | 4,094 | 2,996.91 |
| April | 48,475 | 30 | 16 | 3,029 | 4,650 | 3,343.28 |
| May | 65,786 | 29 | 21 | 3,132 | 4,893 | 3,843.48 |
| June | Dredge rammed and sent to Portland | | | | | 7,438.19 |
| July | 58,682 | 28 | 14 | 4,192 | 7,418 | 3,944.19 |
| August | 30,687 | 14 | 7 | 4,388 | 7,426 | 2,488.95 |
| *September | No work; due to lack of funds. | | | | | |
| October | 6,574 | 17 | 3 | ..... | 3,032 | 3,620.40 |
| Total | 240,121 | 186 | 77 | 3,118 | 7,426 | $34,953.14 |

*There was a small expense in connection with laying the dredge up, for which no record is at hand.

$34,953.14 ÷ 240,121 cu. yds. = 14.6 cents, unit cost of dredging per cu. yd. for the season. Of this the labor cost = 6.8 ct. per cu. yd., and the fuel oil 3.1 ct. per cu. yd. The pump average for the season was 14.6 cu. yd. per minute, or 878 cu. yds. per hour.

The dredge was credited with deepening the bar channel from 17 ft. at mean lower low water to 22 ft. at the same stage of tide, but, as no progress surveys were made of the dredging, nothing definite can be said of the nature of the bar channels during the various months of the season. On resuming operations in May, 1915, the dredge started work on about 19 ft. at mean lower low water.

At the conclusion of the Michie's trial trips and tests, made at Astoria, Ore., in November, it was decided to use a smaller and lighter drag-head, as well as to enlarge the boilers. While the new sections were being built for the enlargement of the pipe boilers, the dredge was loaned to the San Francisco District and operated on Humboldt Bay, Eureka, Cal., from Nov. 17, 1914, to March 1, 1915, dredging the inside channels. The original intention was to carry this dredged material to sea and dump it in deep water, but, due to the continued rough condition of the bar, only a small percentage of the material was disposed of in this way. Most of the material was dumped in blind channels or deep holes inside the bay. The material was mud and fine sand, the work being similar to that done in Bay Ridge Channel by the New York District. The dredge operated from 6 a. m. to 6 p. m., established range lights enabling the dredge to go and return from work in the dark. The original drag-head was used the first month, and a noticeable improvement was apparent in the dredging when this was replaced with a smaller drag-head. The pumping average increased and the ship was much more easily handled.

The following table gives the amount of work done at Eureka and the costs, which include $50 per day rental for the dredge. This rental just about paid for the depreciation of the plant while in that district.

| Month. | Cu. yds. dredged. | Days dredge in commission. | Parts of days worked. | Average amount dredged per day. | Maximum amount dredged per day. | Cu. yds. dredged per minute. | Total expense. |
|---|---|---|---|---|---|---|---|
| 1914— | | | | | | | |
| November | 19,874 | 15 | 11 | 1,897 | 3,006 | 6.15 | $3,081.67 |
| December | 68,605 | 31 | 26 | 2,630 | 4,040 | 11.00 | 6,888.14 |
| 1915— | | | | | | | |
| January | 101,040 | 31 | 25 | 4,041 | 5,850 | 10.00 | 7,095.59 |
| February | 68,152 | 28 | 23 | 2,963 | 5,454 | 8.40 | 6,534.14 |
| Total | 257,667 | 105 | 85 | ..... | ..... | 9.4 | $23,599.54 |

$23,599.54 ÷ 257,667 cu. yds. = $0.09159, approximate unit cost per cu. yd. Of this the labor cost was 2.8 ct. per cu. yd., and the fuel oil was 2.6 ct. per cu. yd. The above figures were taken from the ship's files and are subject to slight variations. The cost per cu. yd. based on place measurement was approximately 10 1/3 ct.

The pumping average is low, though it is good for the class of material the dredge was working in, and is as good as that of other dredges working in the same kind of material with practically the same pumping capacity. The material settled slowly, was full of sticks, pieces of wire rope, and all sorts of trash. The drag-head would bury itself many feet in the material if not closely watched, and the mud adhered to the sides of the bins to such an extent that it took an hour to dump some of the loads, the material having in reality to be washed out.

The Michie arrived on Coos Bay ready for work on May 10, 1915, after having had her boilers enlarged, stern bearings renewed, and having been given a general overhauling.

The weather conditions were not at all favorable in May, and it took that month to get the dredging organized and another crew assembled and broken in for operating the dredge with two crews on the bar from daylight to dark, weather permitting. The dredge was operated throughout the remainder of the season on this basis up to Nov. 19, when it was loaned to the Seattle District to dredge on Grays Harbor Bar. A crew of 35 men was employed.

The following table shows the work as accomplished by months:

| Month. | Cu. yds. dredged. | Days dredge in commission. | Parts of days worked. | Average amount dredged per day. | Maximum amount dredged per day. | Cu. yds. dredged per minute. | Total expense. |
|---|---|---|---|---|---|---|---|
| 1915— | | | | | | | |
| May | 40,520 | 20 | 9 | 4,502 | 7,170 | 22.8 | $6,490.04 |
| June | 210,672 | 30 | 25 | 8,426 | 13,733 | 22.8 | 7,653.99 |
| July | 200,678 | 31 | 22 | 9,121 | 14,137 | 24.5 | 5,793.81 |
| August | 222,623 | 31 | 25 | 8,904 | 14,192 | 25.9 | 7,481.34 |
| September | 135,881 | 30 | 16 | 8,492 | 12,795 | 26.5 | 5,596.71 |
| October | 80,411 | 31 | 13 | 6,185 | 12,168 | 27.1 | 8,076.16 |
| November | 10,919 | 20 | 4 | 2,729 | 4,575 | 22.3 | 5,156.11 |
| Total | 901,704 | 193 | 114 | ..... | ...... | .... | $46,248.16 |

1915—

$46,248.16 ÷ 901,704 = $0.0513, which is the approximate unit cost per cu. yd., which includes a 2 per cent charge for Portland office expense, but does not include any expense of laying the dredge up over the winter or the necessary annual overhauling, which will be required in March, 1916.

Of this unit cost the labor alone was 1.95 ct. per cu. yd., and the fuel oil 1.6 ct. per cu. yd.

Surveys of the bar were made each month, weather and bar conditions permitting, to show the progress made by the dredge. It was not possible to get the first survey made until May 31, 1915, after one month's dredging, due to the bar being very rough.

## ECONOMICS AND COSTS OF MOTOR TRUCK OPERATION.*

### Economics of Truck Operation.

Many things contribute to make southern California an ideal field for the motor truck: perfect operating conditions throughout the year, many miles of good roads, city streets out into the country, a population which has scattered out instead of congesting, cheaper fuel than can be had in any other truck country, and a labor market where intelligent, careful drivers may be had for a moderate wage. For many kinds of haulage, covering a wide range of operation, the motor truck is distinctly superior to any other method of transportation. Given an active service at full load, with a terminal not definitely fixed and a radius of operation up to 30 miles, it is an exceptional condition which will justify any other method of goods haulage.

Some of the especially active fields for the truck in southern California are goods hauling to and from Los Angeles harbor, interurban delivery service, road building and wholesalers' delivery. There are, however, special considerations which may have considerable bearing upon the employment of a truck. A committee of the Boston Chamber of Commerce, in a detailed report on street traffic in Boston, covering eighteen months of study, reported that "development of motor trucks will tend to relieve congestion by moving all merchandise in larger units and more rapidly," and that "the average speed of motor vehicles in getting into and away from railway terminals is from two to three times that of the horse." This is especially applicable to Los Angeles, which has nearly two miles of as congested streets as are to be found in nearly any city.

Another great advantage of the motor truck to the retailer is that he not only can supply his customers more quickly, but also because of the greater mileage range his territory is increased to about eight times what he could serve with a horse.

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*From a paper by W. Howard Clapp, Pasadena, Fla., in the October Journal of American Society of Mechanical Engineers.

### Costs of Gasoline Trucks.

Figure 1 gives curves of cost, weight and horsepower (average values) for all classes of gasoline trucks as listed by publishers of motor truck publications. The noticeable feature of these curves is the sudden break of each for the lighter trucks of less than 1 ton capacity. These show that the demand for a light truck has been met by making a vehicle which is much lighter for the rated load than the heavier trucks. This is possible because of the higher engine speed, a more simple final drive, torque and thrust taken through the vehicle springs, and by the generous use of special alloys and heat-treated steels. The curves suggest that these trucks are too light for the load that they are rated to carry. That this is true is abundantly proved by the records of many light trucks, which show that the average life of a light delivery truck is about 35,000 miles, whereas the heavier trucks when properly driven and cared for can be depended upon to give 80,000 to 100,000 miles, or even more for the better grade of trucks, if they are carefully driven and ordinary maintenance is kept up. It would seem that there is a real field for a more serviceable light truck which will at a little greater cost give enough lower depreciation and maintenance to be a profitable investment.

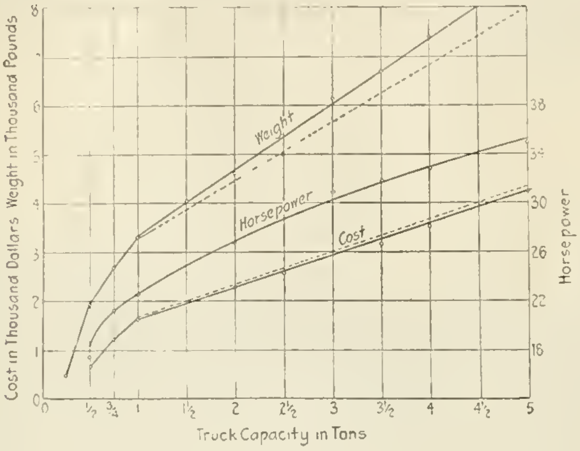


Fig. 1—Averages from All Classes of Gasoline Motor Trucks.

That there is a real field for such a truck not only for city service but also for use throughout the country is shown by the report of the U. S. Government, which states that only 15 per cent of the entire traffic of the country is moved by railroads and steamships combined, the remainder of 85 per cent being carried for the most part in wagons, and the greater part of it in lots of 1,000 lb. or less. This field has only been touched by the motor truck as yet, and to fully occupy it would require not less than two million light trucks. This estimate makes no provision for hauling done on the farm.

Table I is an itemized cost statement for various sizes of gasoline trucks under average service conditions on the roads of southern California. These costs are conservative. It is possible to find plenty of examples of lower costs and also of costs that are much higher, but these costs are easily realizable for ordinary truck work in this locality. With proper management an even lower cost per day should be realized. That these costs are somewhat lower than averages for other localities may be largely credited to good roads and an equable climate. In making this table three conditions of operation are assumed: the costs for each size of truck are computed for a daily run of 25, 50 and 75 miles, and for each condition the life of the truck is estimated, and depreciation is based on this life. Costs are given in dollars for the entire life of the truck. First costs are average chassis costs in Los Angeles.

In California distillate is being used to quite an extent as a substitute for gasoline. The cost per gallon is about half that of gasoline at the present time, and the b. t. u. content somewhat greater. A local truck manufacturer has been very successful in equipping trucks with gasifiers by which the heat of the exhaust gases from the engine is used to heat the inlet air as it goes to the carburetor, and also to heat the mixture as it goes from the carburetor to the cylinder. A supply of gasoline is carried and used in starting. The consumption of distillate is about the same as that of gasoline. The success which has attended this innovation would seem to justify the claims of the manufacturer that the use of distillate does not increase carbon trouble. The question of a lessened volumetric efficiency is a negligible consideration.

Tires will outwear the manufacturers' guarantee at least 25 per cent when used on the good roads of southern California. Smooth roads, dry surfaces and an equable climate all contribute to this result. Overloading and overspeeding are the things that shorten tire life. However, the important consideration is not tire economy, but economy of truck operation per ton of material carried; therefore, durability is only one factor that must be taken into account. Resilience, which prevents the wasting of truck power; cushioning effect, which keeps the maintenance charges low on the whole truck; a good tractive grip and a reasonable cost are all properties which are required in a truck tire.

### Operating Costs.

Figure 2 gives a graphical view of percentage costs for a light, a medium and a heavyweight truck, each averaging 50 miles a day. The higher proportion which the light truck has in the items of labor, depreciation and maintenance is noticeable. Against this increase is the lower percentage of the entire cost charged to fuel and tires.

In discussing motor truck costs it is not possible to neglect the human factor, which here more than in most cases of machinery handling is one of the principal items. It is hardly too much to say that maintenance costs are chiefly driver. An expensive and intricate machine is put in charge of a low-paid employe who is not the owner and who ordinarily has but a limited knowledge of machinery. This is one reason why the life of a light truck is usually about two or three years.

Many of the larger department stores will not allow their drivers to make any repairs or even to carry a wrench or a pair of pliers. A repair force looks after each truck and keeps it cleaned, oiled and set up. Ownership of eight or ten trucks will justify an owner in employing a mechanic who, with a small outfit of tools and a helper, can keep the trucks clean and in adjustment and make many of the smaller repairs. Reliable service garages are now to be found which will do the same work for a reasonable charge, and this is more satisfactory than to leave it to the driver.

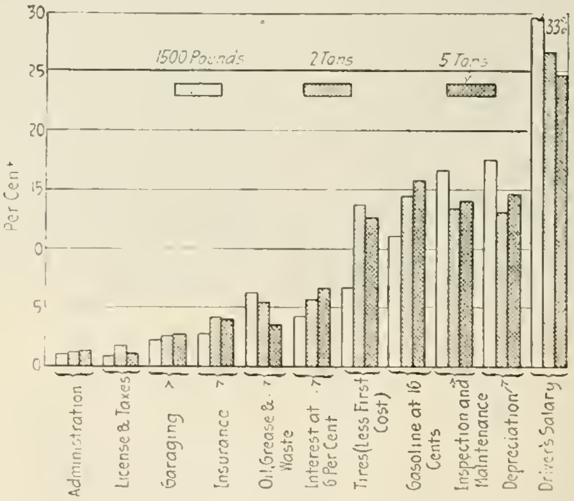


Fig. 2.—Division of Truck Costs.

It is impossible for the manufacturer to devise a shop test that will equal the brutality of actual service. The modern motor truck has had to meet the demand for a vehicle that will stand abuse. The careless or indifferent driver is quick to find this out. Operating costs for the same make and capacity of truck engaged in exactly the same kind of work for one firm will frequently show a variation of 40 per cent in the items of gasoline, oil, tires and maintenance. It is easy to see how a poor driver will shorten the life of a truck.

Manufacturers have tried to meet this condition by making truck parts as few and simple as possible; by standardization of parts; by making wrong assemblies impossible; by printing detailed information about oiling and caring for the truck; and by instituting a follow-up service to get the truck owner started right. The truck governor has helped to solve the speeding problem. Another aid is the recording speedometer, which gives a graphical log of each day's run—velocity plotted against time: thus every minute of the day is accounted for; the number of stops and time of each, maximum speed, etc. The chart will show, for example, whether it will pay to put on a second man to hasten deliveries or whether a rerouting of existing lines will give a better all-around service. A driver's record sheet, if it is brief and informing and filled out each day, is frequently helpful. It must be drawn off at the office and kept up to date. Records are of little use unless changed conditions can be recognized at once.

Lubrication is probably the most important item in truck maintenance. Manufacturers have tried to make oiling simple and easy to do by making oiling places few and accessible, and by providing charts and printed instructions for this work; some parts every day, some parts twice a week, etc. Still, there are about seventy places in the average truck that must be lubricated, and if there is no intelligent head to look after this work local wear soon starts, and then things go fast. Motor oil should be changed frequently, at least once for every 1,000 or 1,500 miles' run. It is not enough to build up the supply, as the oil is fast charged with carbon and with grit from the intake air and soon loses its lubricating qualities.

Figure 3 gives curves for gasoline trucks plotted from the data of Table I. These curves, if continued out to the line of zero miles per day, show the daily fixed charges for each truck. The cost per day increases quite uniformly with the increase in size, of the truck, whether the daily run be a large or a small one. The cost per ton mile is based on a full load each way. This chart shows that under such favorable conditions of haulage a heavy truck may reach a ton-mile cost of as low as 5 ct., provided that the nature of the work is such that the truck can be run daily at the rate of 50 or 60 miles a day. This is a heavy mileage for a big truck, and such an ideal service as would be represented by a full haul each way on level roads, with loading and unloading time minimized so that the truck could be under way for six or seven hours each day and with no extra helper required, is not often found.

In deciding upon a truck one of the most important questions to settle is that of size. On the good roads of this section it is more disastrous to buy a truck too large for the work than to buy one that is too small. A 5-ton truck costs some 25 per cent more to operate than a 3-ton machine, nor is this cost reduced very much by taking a lighter load on the heavier truck. Interest, depreciation, maintenance, taxes, insurance and fuel—all are higher. Until very recently the tendency has been for owners to buy trucks too large for their needs. Now the buyers have commenced to realize that it costs too much to "deliver the vehicle."

Another point that must not be overlooked is that the capacity of a truck is figured for average conditions, and that the average road condition throughout the country is very much harder on the truck than it is here. A half load on a truck carried over a road full of ruts and chuckholes is much worse for the truck than a 20 per cent overload on a good concrete or asphalt road. A 6½-ton truck recently carried an 11-ton casting up the Mount Wilson toll road, a distance of 9 miles. This is a tremendous overload, but it cannot be said that the truck was injured by it. In fact, it is probable that the truck parts were not weakened in any way by this test, for the road, while steep, is firm and smooth. The writer does not wish to encourage overloading, which has been responsible for many truck failures and against which much has been written, but he does wish to point out that an occasional overload of 25 per cent or even 50 per cent when handled carefully on a good road is not a serious matter, while to haul a heavy truck day after day, loaded at half capacity, is a very serious matter if one would haul cheaply.

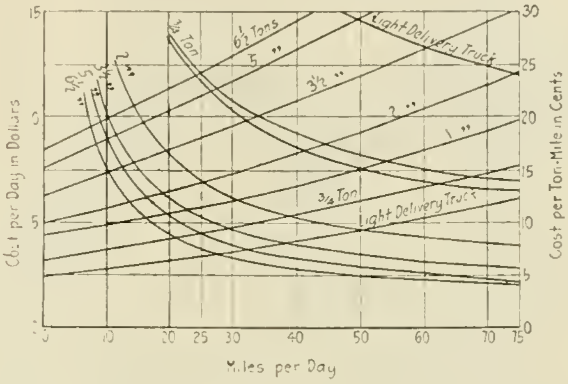


Fig. 3.—Cost of Operating Gasoline Motor Trucks.

TABLE I.—TOTAL COST OF OPERATING GASOLINE MOTOR TRUCKS AT VARIOUS DAILY MILEAGES.

| Capacity of truck. | Cost in dollars. | Horsepower. | Miles per hour. | Miles per gallon of gasoline. | Daily mileage. | Estimated life, years. | Total mileage. | Costs for entire life of truck, in dollars. | | | | | | | | | | | | Cost per day, dollars. | Cost per mile, dollars | Cost per ton-mile, dollars. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Insurance, fire and liability. | License and taxes | Interest at 6 per cent. | Depreciation. | Administration. | Garaging. | Gasoline at 16 ct. per gal. | Oil, grease and waste. | Tires (less first cost). | Driver's salary. | Inspection and maintenance. | Total. | | | |
| Light delivery wagon | 600 | 18 | 25 | 15 | 25 | 5 | 37,500 | 200 | 40 | 180 | 600 | 35 | 180 | 400 | 190 | 225 | 2,400 | 750 | 5,209 | 3.47 | 0.139 | 0.417 |
| | | | | | 50 | 2½ | 37,500 | 100 | 25 | 90 | 500 | 20 | 90 | 400 | 190 | 225 | 1,200 | 655 | 3,495 | 4.66 | 0.096 | 0.288 |
| | | | | | 75 | 1½ | 33,750 | 60 | 20 | 55 | 450 | 10 | 55 | 360 | 170 | 200 | 900 | 505 | 2,785 | 6.19 | 0.082 | 0.246 |
| 1,500 lbs. | 1,100 | 22 | 20 | 12 | 25 | 6 | 45,000 | 300 | 65 | 400 | 1,100 | 110 | 215 | 600 | 340 | 270 | 3,600 | 1,010 | 8,010 | 4.45 | 0.178 | 0.237 |
| | | | | | 50 | 3 | 45,000 | 150 | 50 | 230 | 950 | 55 | 110 | 600 | 340 | 270 | 1,800 | 900 | 5,455 | 6.06 | 0.121 | 0.161 |
| | | | | | 75 | 2 | 45,000 | 100 | 30 | 130 | 850 | 35 | 70 | 600 | 340 | 270 | 1,440 | 790 | 4,655 | 7.76 | 0.103 | 0.137 |
| 1 ton. | 1,875 | 24 | 19 | 8 | 25 | 10 | 75,000 | 850 | 220 | 1,125 | 1,875 | 225 | 480 | 1,500 | 560 | 1,340 | 7,200 | 1,900 | 17,275 | 5.76 | 0.230 | 0.230 |
| | | | | | 50 | 6½ | 97,500 | 550 | 140 | 730 | 1,690 | 140 | 310 | 1,950 | 730 | 1,800 | 4,680 | 1,900 | 14,620 | 7.50 | 0.150 | 0.150 |
| | | | | | 75 | 4 | 90,000 | 300 | 85 | 395 | 1,500 | 90 | 170 | 1,800 | 675 | 1,640 | 3,468 | 1,800 | 11,815 | 9.85 | 0.131 | 0.131 |
| 1½ tons. | 2,150 | 25 | 18 | 7 | 25 | 10 | 75,000 | 1,000 | 235 | 1,290 | 2,150 | 255 | 600 | 1,710 | 560 | 1,505 | 7,200 | 2,000 | 18,505 | 6.17 | 0.247 | 0.165 |
| | | | | | 50 | 6½ | 97,500 | 650 | 150 | 840 | 1,935 | 170 | 390 | 2,230 | 730 | 2,025 | 4,680 | 2,000 | 15,800 | 8.10 | 0.162 | 0.109 |
| | | | | | 75 | 4 | 90,000 | 350 | 95 | 450 | 1,725 | 100 | 210 | 2,055 | 675 | 1,850 | 3,360 | 1,900 | 12,770 | 10.64 | 0.142 | 0.095 |
| 2 tons. | 2,625 | 26 | 17 | 6 | 25 | 10 | 75,000 | 1,150 | 265 | 1,575 | 2,625 | 315 | 720 | 2,000 | 750 | 1,840 | 7,200 | 2,250 | 19,440 | 6.90 | 0.276 | 0.138 |
| | | | | | 50 | 6½ | 97,500 | 750 | 195 | 1,025 | 2,360 | 205 | 470 | 2,600 | 975 | 2,475 | 4,680 | 2,250 | 17,985 | 9.22 | 0.184 | 0.092 |
| | | | | | 75 | 4 | 90,000 | 400 | 110 | 550 | 2,100 | 125 | 250 | 2,400 | 900 | 2,255 | 3,360 | 2,100 | 14,550 | 12.12 | 0.162 | 0.081 |
| 3½ tons. | 3,500 | 32 | 14 | 5 | 25 | 10 | 75,000 | 1,350 | 380 | 2,100 | 3,500 | 415 | 960 | 2,400 | 750 | 2,345 | 9,600 | 3,250 | 25,700 | 9.02 | 0.361 | 0.103 |
| | | | | | 50 | 6½ | 97,500 | 875 | 245 | 1,365 | 3,150 | 270 | 625 | 3,120 | 975 | 3,150 | 6,240 | 3,250 | 23,265 | 11.93 | 0.239 | 0.068 |
| | | | | | 75 | 4 | 90,000 | 460 | 150 | 735 | 2,800 | 165 | 335 | 2,880 | 900 | 2,870 | 3,840 | 3,000 | 18,135 | 15.11 | 0.201 | 0.057 |
| 5 tons. | 4,600 | 35 | 12 | 3½ | 25 | 10 | 75,000 | 1,760 | 440 | 2,760 | 4,600 | 550 | 1,200 | 3,430 | 750 | 2,680 | 10,800 | 4,000 | 32,970 | 10.99 | 0.439 | 0.088 |
| | | | | | 50 | 6½ | 97,500 | 1,145 | 285 | 1,845 | 4,140 | 360 | 780 | 4,460 | 975 | 3,600 | 7,020 | 4,000 | 28,610 | 14.67 | 0.297 | 0.059 |
| | | | | | 75 | 4 | 90,000 | 700 | 180 | 965 | 3,680 | 220 | 480 | 4,115 | 900 | 3,280 | 4,320 | 3,600 | 22,340 | 18.62 | 0.223 | 0.044 |
| 6½ tons. | 5,000 | 40 | 10 | 3 | 25 | 10 | 75,000 | 1,875 | 525 | 3,000 | 5,000 | 590 | 1,320 | 4,000 | 940 | 3,015 | 10,800 | 5,000 | 36,065 | 12.02 | 0.481 | 0.074 |
| | | | | | 50 | 6½ | 97,500 | 1,220 | 350 | 1,950 | 4,500 | 380 | 860 | 5,200 | 1,220 | 4,050 | 7,020 | 5,000 | 31,750 | 16.35 | 0.326 | 0.050 |

It is possible to buy a truck that is suited for work on good roads or one that is especially designed for rough roads, mud, steep hills and severe service generally. The problem is to know what is suited and to weigh properly the arguments of the salesman who offers a 2-ton truck with a 15-hp. motor and a 25-hp. rear axle, and the counter arguments .of his rival, whose truck has a 25-hp motor and a 20-hp. rear axle. This is one of the surprising results of the modern method of building up assembled parts into a truck, and, while there may be advantages of such variations in the relative strength of truck parts for some particular service, it is a fact that both extremes are being sold for exactly the same work. The Society of Automobile Engineers has done a wonderful work in standardizing the parts for auto trucks. This will be carried much further in the future, for the economies that will result from standardized parts and also from standardized assemblies have been strongly emphasized by the experience of European countries with the use of trucks in the present war.

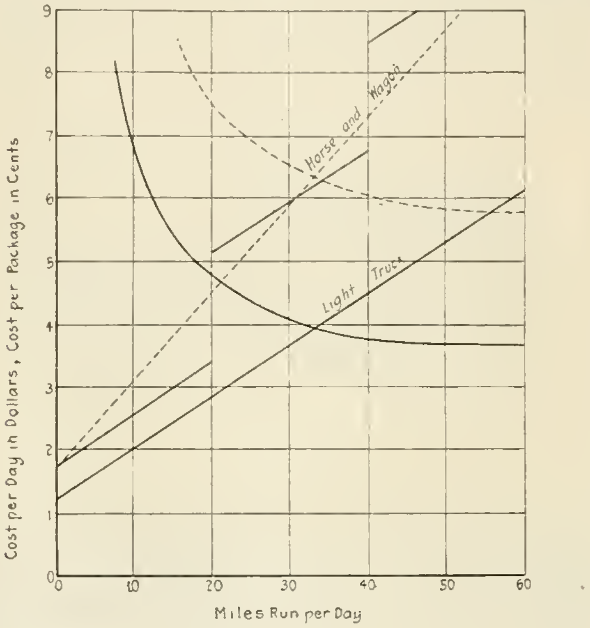


Fig. 4.—Comparison of Single Horse and Wagon and Light Delivery Truck Costs.

At present the truck owner or prospective purchaser is sadly in need of disinterested advice, and there is a good engineering field for the man who thoroughly knows trucks and can plan service. There is little doubt but that the average truck owner could save 20 per cent of his operating costs by properly analyzing his problem.

### Methods of Reducing Trucking Costs.

To get a low cost per ton it is necessary to keep the truck moving. Devices which cut down the time of loading and unloading are very important. Among these are self-dumping bodies of various kinds for stone, hot asphalt of lumber; loading chutes or bins which are filled by elevator or conveyor; there is also a movable steel tipple which can be run alongside a train of flat cars and be filled by shovelers while the truck is out on the road, so that the actual time required to fill the truck is very little. Another device is the use of extra truck bodies, which are loaded while the truck is on the road and swung onto the truck by an air lift or other hoist. A firm of wholesale grocers in Los Angeles is using this method very satisfactorily. In interurban delivery service loading nests or cartridges are being used. These are filled in the store and run out onto the truck. There is some promise in the extension of this device for relieving the congestion around freight stations and also for interurban service where a heavy truck can bring over all of the orders for an entire community and local deliveries be taken care of by light trucks, each with its especial cartridge. A scheme somewhat similar to this is now being tried out by the city of Los Angeles. The incombustible rubbish is gathered by a house-to-house collection, using wagons. The material is put in large cans which are carried to a central point and a heavy truck is used to haul all of the cans to the city dump.

### Comparisons of Operating Costs of Horse-Drawn and Motor Trucks.

The use of an extra man to facilitate deliveries will often save enough time to make a good investment. One of the large department stores in Los Angeles found that on a certain route where one man had averaged 110 stops a day two men were able to make 190 deliveries. The use of self-starters on trucks of this type is also becoming common. These save a little time on each stop and also keep the driver out of the dirt, and particular customers appreciate this feature. At the plant of the Southern California Gas Company the night man unloads the trucks and stores the pipe and old meters that have been collected during the day, and then puts onto the truck the new supplies that have been requisitioned for the coming day.

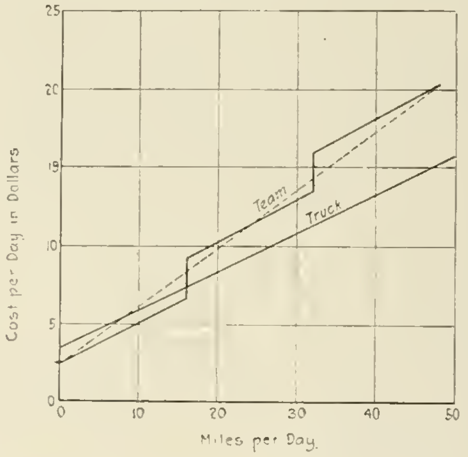


Fig. 5.—Comparison of Costs for 5-Ton Gasoline Truck and Heavy Teams.

Figure 4 and Table II show a comparison between the

TABLE II.—COMPARISON OF OPERATING COSTS OF A SINGLE-HORSE WAGON AND A LIGHT GASOLINE DELIVERY TRUCK.

Cost of wagon equipment (horse, $250; wagon, $140; harness, $40), $430.
Cost of 700-lb. capacity gasoline truck, $600.

| | Wagon costs. | | Truck costs. | |
|---|---|---|---|---|
| | Idle. | 20 miles per day. | Idle. | 60 miles per day. |
| Estimated life, years | 10 | 10 | 10 | 2.5 |
| Depreciation | $0.108 | $0.156 | $0.200 | $0.760 |
| Interest at 6 per cent | 0.086 | 0.086 | 0.120 | 0.120 |
| Taxes | 0.009 | 0.009 | 0.012 | 0.012 |
| Stable and garage rent | 0.200 | 0.200 | 0.166 | 0.166 |
| Insurance (fire and theft) | 0.030 | 0.030 | 0.045 | 0.045 |
| Driver (⅓ time when idle) | 0.666 | 2.000 | 0.666 | 2.000 |
| Feed— | | | | |
| Hay, 10 lb. and 15 lb. | 0.102 | 0.153 | ..... | ..... |
| Oats, 10 qt. and 15 qt. | 0.206 | 0.300 | ..... | ..... |
| Gasoline, at 16 ct. per gal. | ..... | ..... | ..... | 0.640 |
| Lubricating oil, at 10 ct. | ..... | ..... | ..... | 0.130 |
| Hostler (1 man to 12 horses) | 0.200 | 0.300 | ..... | ..... |
| Cleaning and oiling | ..... | ..... | ..... | 0.400 |
| Shoes and veterinary | 0.095 | 0.135 | ..... | ..... |
| Tires and tubes | ..... | ..... | ..... | 0.625 |
| Repairs to wagon | ..... | 0.090 | ..... | ..... |
| Maintenance | ..... | ..... | ..... | 1.200 |
| Water, bedding, etc. | 0.045 | 0.045 | ..... | 0.005 |
| Total cost per day | $1.741 | $3.401 | $1.209 | $6.103 |

TABLE III.—COMPARISON OF OPERATING COSTS OF A 5-TON GASOLINE TRUCK AND A HEAVY TWO-HORSE WAGON.

Cost of wagon equipment (2 draft horses, $600; wagon, $300; harness, $100), $1,000.

Cost of 5-ton gasoline truck, $4,800.

| | Wagon costs | | Truck costs | |
|---|---|---|---|---|
| | Idle. | 16 miles per day. | Idle. | 50 miles. per day. |
| Depreciation | $ 60 | $ 120 | $ 240 | $ 480 |
| Interest | 60 | 60 | 288 | 288 |
| Taxes | 6 | 6 | 30 | 30 |
| Stable or garage | 120 | 120 | 120 | 120 |
| Insurance (liability) | ... | 26 | ... | 140 |
| Driver | 250 | 750 | 360 | 1,080 |
| Helper | ... | 600 | ... | 600 |
| Feed or gasoline | 90 | 135 | ... | 686 |
| Oil, grease, waste, etc. | ... | 5 | ... | 150 |
| Shoes and veterinary, or tires | 25 | 40 | ... | 550 |
| Repairs, maintenance | ... | 25 | ... | 600 |
| Water, bedding, etc. | 25 | 25 | ... | 20 |
| Hostler | 100 | 100 | ... | ... |
| Total cost { Per year | $736 | $2,012 | $1,038 | $4,744 |
| Total cost { Per day | $2.45 | $6.70 | $3.46 | $15.81 |

cost of running a light gasoline delivery truck such as is used for close-in delivery work by grocers and the cost of running a one-horse delivery wagon. The costs are from actual costs gathered in Los Angeles and vicinity and averaged. For each vehicle the cost is figured for the vehicle idle and again when running at a fair maximum daily average. The figures show that there is no excuse for using a horse for this kind of work, whether the number of deliveries be large or small. Twenty miles a day is a maximum for any delivery horse if used 300 days a year. If more than 20 miles a day are to be covered, it is necessary to duplicate equipment.

Figure 5 and Table III give a similar comparison between the cost of operating a 5-ton gasoline truck and heavy teams used for such work as rock and dirt haulage and heavy transfer work generally. As in Fig. 5, the costs are figured from actual costs based on a maximum of service per day and an assumption as to what the costs would be if the vehicle did no work. The curves show that the truck should have enough work to do to occupy the time of more than one team, if it is to be the cheaper vehicle. The Pacific Electric Railway Co. uses heavy trucks for patching and paving along the line. They find that for work outside the business district the truck will do the work of two or three teams, depending upon the length of haul and the size of the job; for long-distance hauling the truck will do the work of four or five teams.

In paving Vernon Ave. the rock and crushed stone were delivered by teams, the average haul being about two miles. Each team delivered a 3-ton load and averaged 5½ trips per day. When work on other contracts took the teams away the work was sublet to another contractor, who took the job at the same price per ton as the teams were figured to have cost. Three 5-ton trucks averaged 12 trips per day each, and carried an average of 54.7 tons per day apiece. This makes each truck equivalent to 3.3 teams, which would represent a considerable saving by the use of trucks, provided they could be kept steadily employed.

The use of electric trucks for delivery service is not so general in Los Angeles as in most large cities. Two of the largest department stores in Los Angeles use no electrics, and other stores which do use them have usually a smaller percentage of the entire fleet of this type. There are two reasons for this: First, a smaller congested area than cities like Boston or Chicago; and, second, a smaller number of stops per mile. For light delivery service where the vehicles carry 1,000 lb. or less the higher first cost of the electrics is a serious objection; for vehicles in the 1,500-lb. class the difference in first cost is not so great, and the electric vehicle will show a lower cost per delivery than the gasoline truck where the latter is held down to the same number of miles per day. Table IV gives the average work and costs for one month for both classes of vehicles for one of the large department stores in Los Angeles. From this it will be seen that, where the electric truck gives a cheaper delivery, it has the advantage of more stops per mile. It is probable that in spite of the close-in traffic conditions the gasoline truck would cover the same route in less time or give a larger number of deliveries per day in the same territory. These costs are based on the use of two men with the gasoline truck and one man on the electric. The comparison shows that the advantage in favor of the electric truck is a very small one, and may vanish altogether under comparative tests. On the other hand, there is an advantage for the electric in its quieter operation and greater cleanliness that is worth something in delivery service.

TABLE IV.—COMPARISON OF GASOLINE AND ELECTRIC DELIVERY TRUCKS.

(Averages for 1 month.)

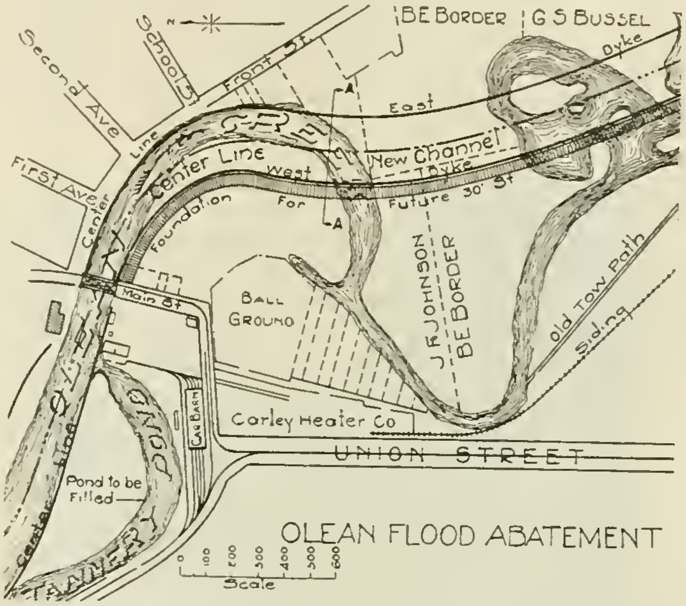
| Type of truck. | Gasoline. | Electric. |
|---|---|---|
| Miles traveled per day | 75 | 36 |
| Stops per mile | 1.96 | 2.74 |
| Stops per day | 147 | 104 |
| Cost per mile, cents | 12 | 15.3 |
| Cost per stop, cents | 6.12 | 5.29 |

## HOW OLEAN, N. Y., PROMOTED AND FINANCED A $300,000 FLOOD ABATEMENT PROJECT.

The city of Olean, N. Y., is making an 8½ mile river improvement, which is a striking example of what may be accomplished by intelligently directed community cooperation.

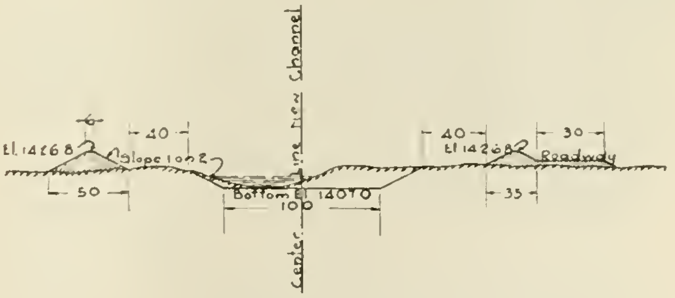
Until the spring of 1913 Olean's flood troubles were regarded as merely a local matter affecting only the owners and occupants of the lower lands. About this time the city became imbued with the idea of reorganizing its Chamber of Commerce on the community betterment plan. The idea found such general favor that it was possible to triple its membership and increase its income over 1,000 per cent.

One of the first tasks undertaken by the new organization was the solving of the flood problem. A committee of representative citizens was formed by the Chamber of Commerce, and unlike in the case of previous efforts, it was made up of men who had no personal interest in the abatement of floods. After a thorough study of the subject a plan was recommended and adopted by the Common Council; a bill introduced in the state legislature appropriating $150,000 contingent upon the city of Olean raising a like amount.



General Layout of Olean Work.

After two years of effort this bill became a law and the local appropriation carried by the taxpayers by a vote of six to one. A Flood Abatement Commission came into existence under the statute. O'Connor & Chapman, of Albany, N. Y., were employed as executive engineers and prepared plans subject to the approval of the Superintendent of Public Works, State of New York, for a flood prevention system which involves the straightening, widening and deepening of the channels and the building of an 8½-mile earthen dike as well as the installation of 6 electrically driven pumping plants, which will take care of the sewage and the discharge of lateral streams at flood time.



Cross Section of Channel Excavation.

The James M. Hamilton Contracting Co. of New York was awarded the content. This company has $50,000 worth of plant on the ground and a force of over a hundred men working day and night with the hope of having the bulk of the work completed before the closing in of winter.

The accompanying cuts show how the new channels are provided for the Olean Creek and the bends are cut off, which shorten the stream over three-quarters of a mile within the city limits.

Notwithstanding the fact that the funds did not become available until Sept. 15, 1915, the plans have been made, approved by state authority, the contract let and the work about one-third completed. This project is believed to hold the record for speed as it ordinarily requires two years to secure plans for this type of work and their approval by state and federal authorities. This is stated to be the largest flood abatement project ever undertaken in the state and has received the largest single appropriation ever made by the state for a similar purpose.

The financing of this project was accomplished primarily through an educational campaign consisting of newspaper publicity, illustrated lectures and personal interviews and the dissemination of information in every possible manner until the entire community became thoroughly informed on the project and got solidly behind it.

The Osgood Shovel on 18-Ft. Sewer Trench Cut.

In addition to the $300,000 provided by the city and state the individual land owners and corporations, whose properties are affected by the work, have contributed over $200,000 worth of lands and service in the way of bridge extensions and other alterations to their property made necessary by the work. Besides the right of way over a hundred acres of lands have been donated to the city, which will be graded in connection with the flood abatement work and afterwards used as parks and playgrounds. Many of these lands have frontage on principal streets, and when the improvement is completed will have a value little short of the total cost to the city of the entire project.

## TRENCH EXCAVATION WITH STEAM SHOVEL.

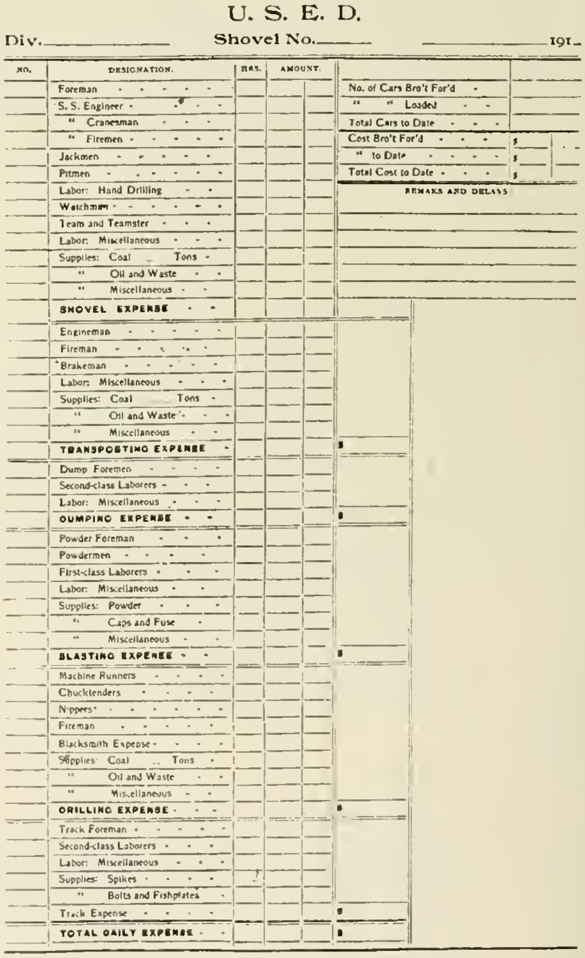
Trenching in sewer construction with steam shovels is a comparatively recent development in the excavation field. In the last few years, however, this excavating method has been much used on many large sewerage undertakings. The accompanying illustration shows a shovel that has been used extensively for work of this kind. This is the Osgood Model 18, revolving traction steam shovel, manufactured by the Osgood Co., Marion, O. The shovel shown is equipped with boom raising and lowering device.

This latter device, which also is used on other makes of shovels, adds much to the flexibility of the digging optrations. By means of it the boom can be raised to the highest possible angle, so that it can make high cuts and load to an extreme height. It also permits the boom to be lowered to an almost horizontal position for making deep cuts, dumping material at the furthest possible distance from the shovel, and enables the shovel to be moved under trolley wires and other low obstructions.

The shovel shown in the halftone is equipped with 19-ft. dipper handle and is excavating to a depth of 18 ft. A ¾-yd. dipper was used on this particular job. In recent work the Osgood 18, equipped with the boom raising and lowering device, is stated to have excavated a sewer trench 46 in. wide, 15 ft. deep and 150 ft. long in a 9-hour day. The material consisted of very dry and hard clay mixed with boulders. After the pipe was laid the shovel refilled the trench. On another job this machine, similarly equipped, excavated a sewer trench 17 ft. deep, 9 ft. wide and 76 ft. long in 7½ hours, loading one half of the material into wagons and depositing the other half on one side of the trench.

## REPORT FORM FOR STEAM SHOVEL WORK.

A steam shovel report form that was used to a considerable extent by the U. S. Corps of Engineers in the construction of the Dalles-Celilo Canal, is shown below. This form, which is reproduced from The Excavating Engineer, was prepared by Mr. L. T. Russell, now western sales agent of the Bucyrus Co., at the time work was started on the canal. The form was intended for use in connection with foremen's slips which were turned in daily. One of these slips was made up by the dump boss, one by the steam shovel engineer and one by the general foreman. Each showed the number of men employed, together with their rates of pay and the hours worked. The three together were intended to cover all material and labor used in connection with one day's work. Each evening or on the following morning the timekeeper filled out the report blank from the information given on the above mentioned slip. This he supplemented to a limited extent from his own time book. A good feature of this form is that it not only gives the record of the day's excavating



U. S. E. D.

Div.________ Shovel No._____ ________191_

| NO. | DESIGNATION. | HRS. | AMOUNT. | | |
|---|---|---|---|---|---|
| | Foreman | | | | |
| | S. S. Engineer | | | | |
| | " Cranesman | | | | |
| | " Firemen | | | | |
| | Jackmen | | | | |
| | Pitmen | | | | |
| | Labor: Hand Drilling | | | | |
| | Watchman | | | | |
| | Team and Teamster | | | | |
| | Labor: Miscellaneous | | | | |
| | Supplies: Coal __ Tons | | | | |
| | " Oil and Waste | | | | |
| | " Miscellaneous | | | | |
| | **SHOVEL EXPENSE** | | | | |
| | Engineman | | | | |
| | Fireman | | | | |
| | Brakeman | | | | |
| | Labor: Miscellaneous | | | | |
| | Supplies: Coal __ Tons | | | | |
| | " Oil and Waste | | | | |
| | " Miscellaneous | | | | |
| | **TRANSPORTING EXPENSE** | | | | $ |
| | Dump Foremen | | | | |
| | Second-class Laborers | | | | |
| | Labor: Miscellaneous | | | | |
| | **DUMPING EXPENSE** | | | | $ |
| | Powder Foreman | | | | |
| | Powdermen | | | | |
| | First-class Laborers | | | | |
| | Labor: Miscellaneous | | | | |
| | Supplies: Powder | | | | |
| | " Caps and Fuse | | | | |
| | " Miscellaneous | | | | |
| | **BLASTING EXPENSE** | | | | $ |
| | Machine Runners | | | | |
| | Chucktenders | | | | |
| | Nippers | | | | |
| | Fireman | | | | |
| | Blacksmith Expense | | | | |
| | Supplies: Coal __ Tons | | | | |
| | " Oil and Waste | | | | |
| | " Miscellaneous | | | | |
| | **DRILLING EXPENSE** | | | | $ |
| | Track Foreman | | | | |
| | Second-class Laborers | | | | |
| | Labor: Miscellaneous | | | | |
| | Supplies: Spikes | | | | |
| | " Bolts and Fishplates | | | | |
| | Track Expense | | | | $ |
| | **TOTAL DAILY EXPENSE** | | | | $ |

| | | |
|---|---|---|
| No. of Cars Bro't For'd | | |
| " " Loaded | | |
| Total Cars to Date | | |
| Cost Bro't For'd | $ | |
| " to Date | $ | |
| Total Cost to Date | $ | |

**REMARKS AND DELAYS**

Report Form for Steam Shovel Work.

and the cost thereof, but it carries forward each day the amount of excavation done to date, as well as the cost. This report blank worked out very well in practice.

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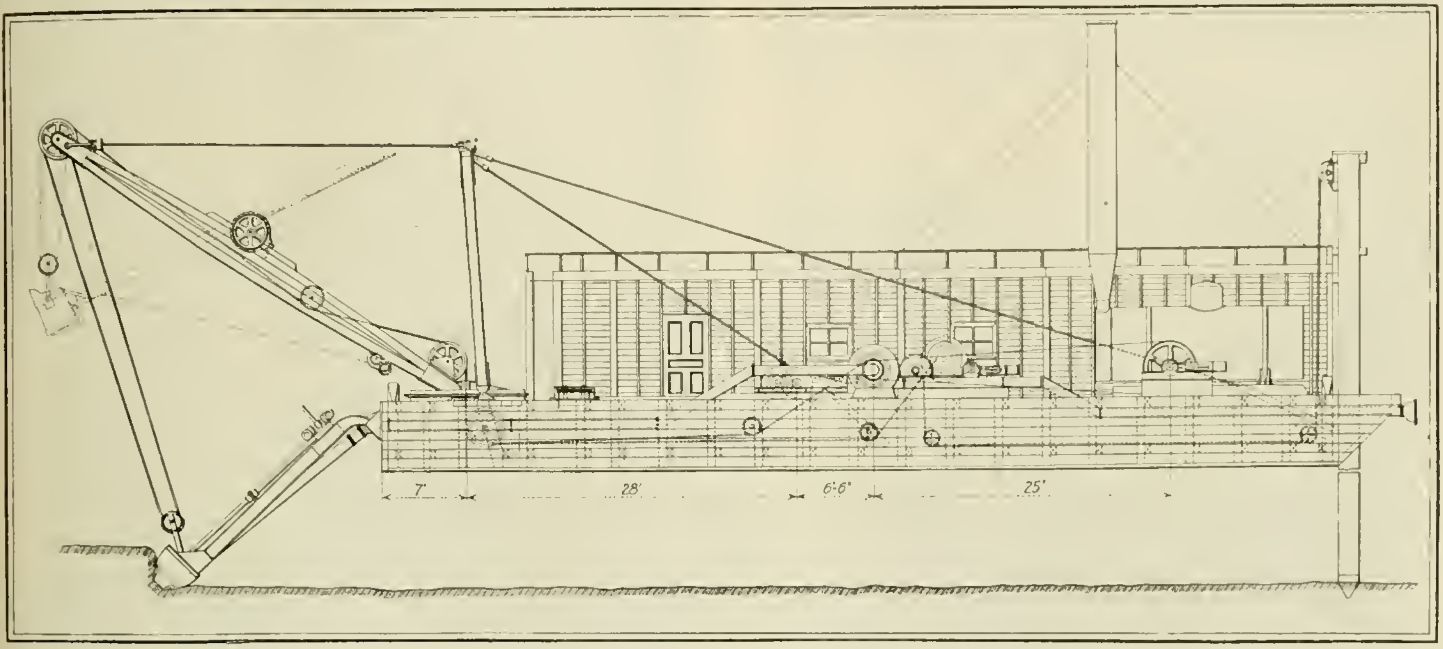
## COMBINATION HYDRAULIC AND DIPPER DREDGE.

A combination hydraulic and dipper dredge will be used by the State Department of Public Works of Ohio for maintenance work and other purposes on Lake St. Marys, one of the artificial bodies of water controlled by the state. This lake has an area of about 19,000 acres and the earth for the construction of the embankments was taken from borrow pits.

The Department intends to pump these borrow pits full of earth and also to construct artificial islands in the lake. The dipper feature was included in order to construct channels and to remove stumps in the lake. The contract price for the dredge, shown in the illustration, including hull and one 20 by 40 ft. scow, together with 400 ft. of pontoon pipe, was $13,900. The idea was evolved by H. R. Klepinger, Assistant Superintendent State Department of Public Works.



Combination Hydraulic and Dipper Dredge of Ohio Department of Public Works.

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## COMPARATIVE COSTS OF CHURN DRILLING WITH STEAM AND ELECTRIC POWER.

Interesting comparative costs of churn drilling with steam and electric power are given in a paper by Mr. Arthur Notman, Bisbee, Ariz., in the recently issued Transactions of the American Institute of Mining Engineers. The drilling was done in connection with the prospecting of Sacramento Hill, which is a mass of granite porphyry intruded along a fault between Paleozoic sediments and pre-Cambrian schists in the Bisbee District, Cochise County, Arizona.

The general plan adopted for the drilling of Sacramento Hill was outlined as follows:

1. The drilling of a line of holes to crosscut the area of the hill between the two well-mineralized areas at either end. The purpose of this work was to determine at the earliest moment the approximate extent of the ore bodies.

2. a. In case the ore bodies were proved continuous by (1), the whole area of the hill was to be drilled at the corners of 200-ft. squares, with intermediate holes where the irregularity in outline of the ore seemed to require it.

b. In case this work proved the central portion of the hill to be barren, the work was to be laid out on 100-ft. squares, with the ore developed underground as starting points. Here, too, when it seemed necessary, intermediate holes were to be driven.

With these objects in view, a road was constructed to drill the line of holes called for by (1). These holes showed no ore, and consequently the plan described under (2-b) was adopted and the roads laid out on the ground to cover the ore bodies and their probable extensions with 100-ft. squares, with the minimum amount of road building.

The cost of the road building for the period considered was as follows:

| | |
|---|---|
| Labor and supplies | $22,065 |
| Footage of road | 15,092 |
| Cost per foot | $1.02 |

About this time, owing to the expense of delivery of the coal and the proximity to the central power house, it was decided that some cheaper power could be secured, and finally electrical power was decided upon as offering the most advantages and the fewest disadvantages. Accordingly, two No. 22 Armstrong drilling rigs without engines or boilers were secured and equipped with 25-h.p., 230 volts, 94 amperes, 400 to 1,200 r. p. m. motors.

At the same time an arrangement for steering the machines when moving was devised and installed on each machine. The moving was accomplished by means of "dead men" and the drilling rope and reel. This arrangement was somewhat less convenient than that of the steam drill, which was self-propelling. A transmission line 2,860 ft. long, of the following specifications, was installed from the power house at the following cost:

2,860 ft. cable, 0000 rubber-covered standard.
1,500 ft. cable, 00 flat mining machine (cut into 250-ft. lengths).

| | |
|---|---|
| Labor | $ 487 |
| Supplies | 1,435 |
| Total | $1,922 |

From the main line, which was run approximately parallel to the axis of the hill, temporary lines of the flat cable were run to the drill locations.

Tables I and II give the costs obtained in this work. The figures for No. 1, or the steam drill, cover a period of 22 months, during which time 12,153 ft. were drilled in outside ground and 16,617.5 ft. in Sacramento Hill. The figures for the Nos. 2 and 3 electric drills cover a period of only 3½ months.

TABLE I.—NO. 1 CHURN DRILL (OPERATED BY STEAM).

| | Cost per foot. | |
|---|---|---|
| Labor: | | |
| Drilling | $0.469 | |
| Casing | 0.073 | |
| Fishing | 0.020 | |
| Moving | 0.197 | |
| Repairing | 0.121 | |
| | | $0.881 |
| Supplies: | | |
| Coal | $0.133 | |
| Casing | 0.046 | |
| Drilling tools | 0.100 | |
| Cordage | 0.081 | |
| Miscellaneous | 0.062 | |
| | | $0.422 |
| Storehouse, water line, air line, and steam line | | $0.029 |
| Total | | $1.402 |

Footage drilled, 28,770½.
Footage drilled per 8-hr. shift, 1 17
Initial costs, $3,734.

TABLE II.—NOS. 2 AND 3 CHURN DRILLS (OPERATED BY ELECTRICITY).

| | Cost per foot. | |
|---|---|---|
| Labor: | | |
| Drilling | $0.466 | |
| Casing | 0.146 | |
| Fishing | 0.072 | |
| Moving | 0.204 | |
| Repairing | 0.084 | |
| | | $0.973 |
| Supplies: | | |
| Casing | $0.021 | |
| Drilling tools | 0.066 | |
| Cordage | 0.093 | |
| Miscellaneous | 0.194 | |
| | | $0.373 |
| Electric power | | 0.033 |
| Teaming | | 0.045 |
| Total | | $1.425 |
| Footage drilled, 8,294. | | |
| Footage drilled per 8-hr shift, 15.2. | | |
| Initial costs, $6,579. | | |
| Electric power line: | | |
| Labor, $487. | | |
| Supplies, $1,435 | | |
| Grand total drills Nos. 2 and 3, $20,322. | | |
| Grand total drill No. 1, $44,060. | | |
| Assaying cost, $1,132. | | |
| Roads: | | |
| Labor, $21,065. | | |
| Supplies, $1,010. | | |
| Grand total | | $2.385 |
| Total footage, 37,064½. | | |
| Average depth of hole, feet, 427. | | |
| Footage of roads, 21,814. | | |
| Cost per foot of roads, $1.01. | | |

The following table gives the cost for the steam drill on Sacramento Hill alone:

TABLE III.—NO. 1 CHURN DRILL (SACRAMENTO HILL).

| | Cost per foot. | |
|---|---|---|
| Labor: | | |
| Drilling | $0.463 | |
| Casing | 0.076 | |
| Fishing | 0.015 | |
| Moving | 0.178 | |
| Repairing | 0.104 | |
| | | $0.836 |
| Supplies: | | |
| Coal | | 0.102 |
| Miscellaneous | | 0.112 |
| Water lines | | 0.014 |
| Teaming | | 0.051 |
| Total | | $1.115 |
| Footage drilled, 16,617½. | | |
| Footage drilled per 8-hr. shift, 20.4. | | |
| Teaming estimated. | | |

It is not quite fair to compare the figures in Table III with those for the electric drills, as the larger part of the work by No. 1 was done in nearly barren ground of uniform character, while that of the electric drills was done entirely in ore-bearing ground, where the changes from strongly silicified leached capping to soft enriched ore, and harder primary material, rendered the drilling much more difficult. For a three months' period, in which the drills were working under essentially similar conditions, the following figures were obtained:

OPERATING EXPENSE.

| | No. 1 Steam. | No. 2 Electric. | No. 3 Electric. |
|---|---|---|---|
| Cost per foot | $1.34 | $1.56 | $1.15 |
| Footage drilled | 4,169 | 3,198 | 4,510 |

Analysis of the working conditions shows that No. 2 drill was operating in exceptionally bad ground and that. while not conclusive, these figures indicate that eventually the electric drills should be operated at from 10 ct. to 25 ct. per foot cheaper than the steam drill, under the conditions obtaining.

The work was conducted as follows: It was carried out under the immediate supervision of a drill superintendent, and operations were continuous in three 8-hour shifts, excepting on Sundays. Each shift on each machine consisted of one driller, one helper and one sampler. There was also a chief sampler, who was responsible for the sampling on all drills. On day shift there was one team with a driver and helper for approximately half a shift to deliver coal for the steam drill, wood for drying samples, to haul supplies, repair parts to and from the machine shop, casing, samples and miscellaneous equipment when the drill was moving from one hole to another. The electric drills were equipped with portable forges operated by electric motors, while the steam drill was equipped with a forge operated by a small steam turbine. Both smithing coal and coke were used in these forges.

The routine duties of the various members of the crew were as follows: The driller was in charge of and operated the machine; the helper oiled the machine, dressed bits and assisted and relieved the driller when necessary; the sampler arranged for the sampling of the sludge every 5 ft., the drying of the sample, the tagging and recording of the sample and its transportation to the assay office. When not engaged in sampling he was at the call of the driller for repairing, bit setting or moving. The chief sampler, one-half of whose time was devoted to the supervision of underground sampling, had general charge of the drill sampling and kept the office records up to date.

In the costs given the sampler's time is included in the labor charge, as only a small portion of his time is really chargeable to sampling.

The tools used were standard and are of no particular interest in a discussion of costs, excepting that lack of proper tools, or a sufficient number of them, is undoubtedly a most frequent cause of high labor costs in churn drilling. The labor and supply charges for casing depend entirely on the character of the ground drilled, and so comparisons of these items for the two kinds of machines are of no value. The time lost in fishing depends on the character of the ground, the supply of tools and the nature of the power. Experienced drillers operating a steam drill are able to tell immediately when there is danger of the tools sticking by the character of the exhaust, and by taking necessary precautions can avoid undue strain on the drilling rope and possible loss of the tools. In the case of the motor-driven drill this becomes a matter of much more delicate observation. and to inexperienced men offers considerable difficulty. This is indicated by the increased loss of time in fishing with the electric over the steam drills and the slightly increased cordage expense.

The labor of moving is practically the same with both types of drill. The repair labor item for the steam drill is higher, due partly to inherent disadvantages and partly to the fact that it was a second-hand machine.

In considering the cost of power on the two types we encounter the widest difference in the cost of operation. Unfortunately, the cost of teaming on the steam drill, at least 60 per cent of which is chargeable to the coal, is not very accurate, owing to the fact that stable expense in the past has been very roughly segregated. This would indicate a cost of 17½ ct. per foot for the coal and another 2½ ct. for pipe lines, or a total of 20 ct. per foot.

Electric power cost only 3.3 ct. There is no teaming to be charged against it, while the proper charge for the installation of the power line depends on the amount of drilling to be done. For a minimum of 30,000 ft. this would amount to 6.4 ct. per foot, or a total of 9.7 ct. per foot, or less than one-half the power cost of the steam drill.

The 4 ct. difference in the item of drilling tools in favor of the electric drill is more apparent than real, inasmuch as the steam machine was put into commission more than a year prior to the starting of the electric drills, and some of the tools then purchased have been used on all machines.

The 13 ct. difference in miscellaneous supplies in favor of the steam drill, on the other hand, is due to the fact that a considerable portion of this item might very reasonably have been charged to initial costs.

The initial costs include the purchase price of the machines, the freight and, with the exception just noted, all additional permanent equipment.

The road building completed is sufficient for a total of 60,000 ft. of drilling to an average depth of 400 ft., or a cost of 36.8 ct. per foot of hole drilled. The assaying cost amounts to 3.5 ct. per foot.

The initial costs of the three machines, distributed over a minimum of 60,000 ft., amount to 17.2 ct. per foot.

These figures would indicate the following complete costs for 60,000 ft. of drilling:

| | Cost per foot. |
|---|---|
| Initial costs | $0.17 |
| Operating expense | 1.43 |
| Road building | 0.37 |
| | $1.97 |

A salvage of 7 ct. a foot on the initial costs might be reasonably allowed, and it seems probable that the operating expense can be lowered another 5 ct. to 10 ct. per foot, giving an average cost of about $1.80 per foot for a minimum of 60,000 ft. of drilling.

The conclusions warranted by the costs obtained so far are:

1. That 60 to 75 per cent of the operating cost is labor.
2. That the labor item is materially affected by the supply of tools and the accessibility to a machine shop for heavy repairs.
3. That the choice of power in churn drilling cannot affect the costs obtained, excepting to a very minor extent. In the present case the low cost of electrical power, due to the proximity to the central power house, determined the selection.

## A CAR UNLOADING DEVICE.

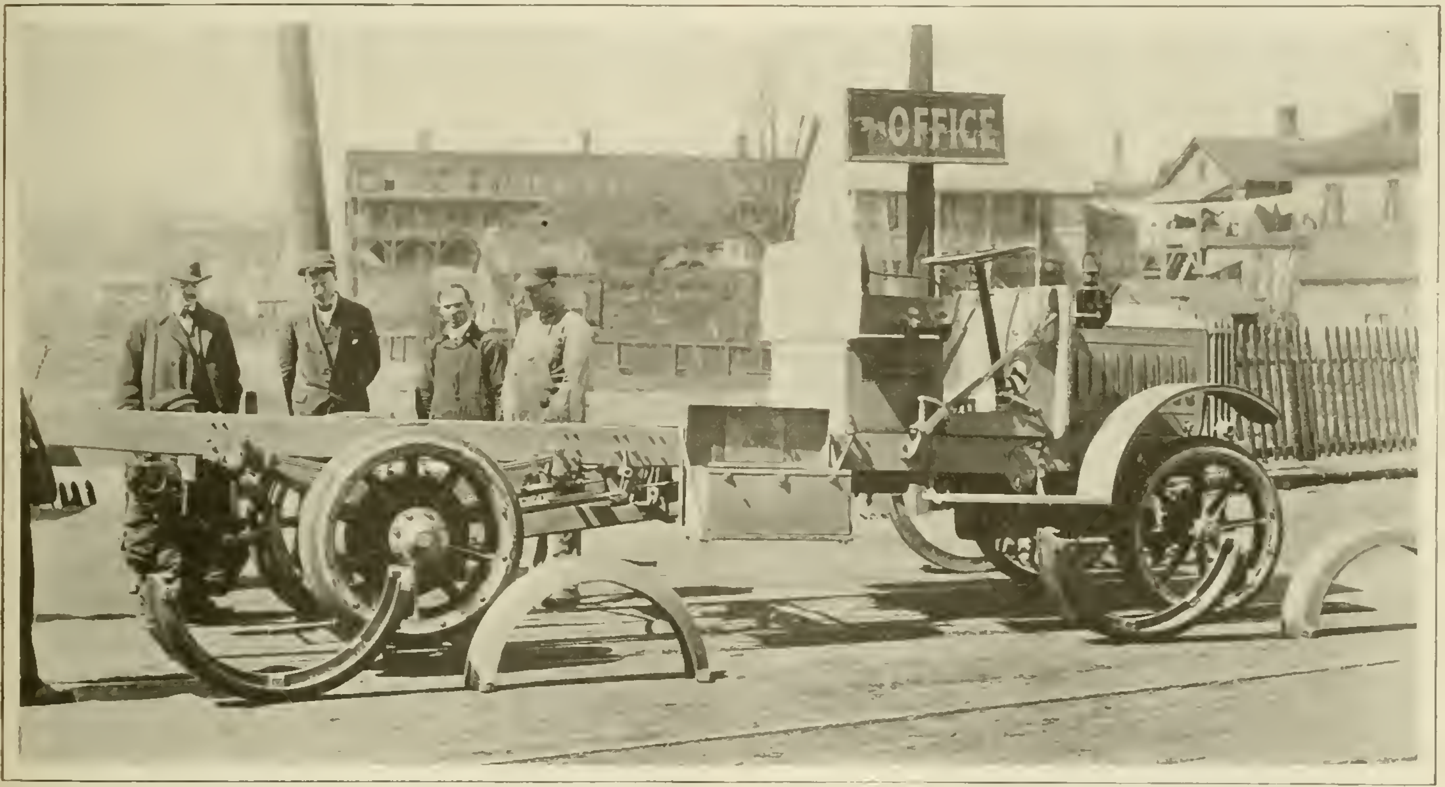
The difference between profit and loss in hauling often depends upon the time required to load the wagons or trucks. In general motor truck operation, for example, the average truck loses more time at the loading station than at any other point on its entire route. Numerous devices have been invented to facilitate loading operations. The accompanying illustration shows one of particular interest to contractors. This is the "Lightning" Loader Skip, manufactured by the Heltzel Steel Form & Iron Co., Warren, O. This skip is easily and quickly attached to a steel or wooden railroad car. The height is adjustable—it is applicable to a high or low car. The angle of dump is controlled by means of a lever. The gate opens by gravity, retarding materials and preventing an overthrow across the wagon or truck. The loader skip is made in two sizes: 1 cu. yd. and 1½ cu. yd., the complete weight of the former being 325 lbs., and of the latter 410 lbs. It is so constructed that it can be quickly dismantled and handled with ease by one or two men.

The Heiskel "Lightning" Loader Skip.

## SPECIAL RIMS FOR ADAPTING MOTOR TRUCK TO RAILROAD TRACK.

Detachable rims for use on motor truck wheels to enable them to run on railroad tracks have been developed recently. The possibilities of this invention were pointed out in an editorial in the July 19 issue of Engineering and Contracting, reference being made to the employment of trucks for the transportation of U. S. troops. The detachable steel flanges used on these trucks were invented and perfected by Mr. A. L. Riker, vice-president and chief engineer of the Locomobile Co. of America, Bridgeport, Conn. The accompanying illustration shows a Riker truck being fitted with the flanged steel rims.

The flanges are made of steel, cast and machined in one piece and sawed apart at the bolt lugs. The inside fits the rubber tire exactly. To put them on, the car is jacked up, the flanges placed over the rubber tires and pounded into place with a mawl, and the bolts inserted and drawn up tight. With two men working at each wheel the complete set of flanged rims can be put on or removed in from 10 to 15 minutes.



Riker Truck Being Fitted With Flanged Steel Rims.

## METHODS FOR DETERMINING SUBSIDENCE AND SHRINKAGE IN EARTHEN EMBANKMENT.

Some interesting methods are being used by the Board of Levee Commissioners of the Orleans Levee District for determining the subsidence and shrinkage in earthen embankments now being constructed in the district. For this purpose 2-in. and 3-in. test pipes are placed, their distance apart depending entirely on ground conditions.

On rear levees, especially along canals, bayous or through prairie and marsh lands, pipes are placed every 300 to 500 ft. At present they are placed every fifth station and along the center line of the levee. The length of pipes depends upon ground conditions, such as strata formation and gross height of levee.

Upon one particular levee the section and grade and conditions are as follows: Crown, 10 ft. wide; slopes, 3:1; net fill, 8 ft., with 20 per cent added for shrinkage, making gross fill about 9.6 ft. The contractors are being paid for pit measurements, subsidence and shrinkage being taken for a record. On all previous contracts the contractors were paid for the net section in embankment, but were required to build the levee to the gross height (being 20 per cent above the net fill), as indicated by dotted lines on the sketches, subsidence as measured being allowed and paid for at the contract price per cubic yard.

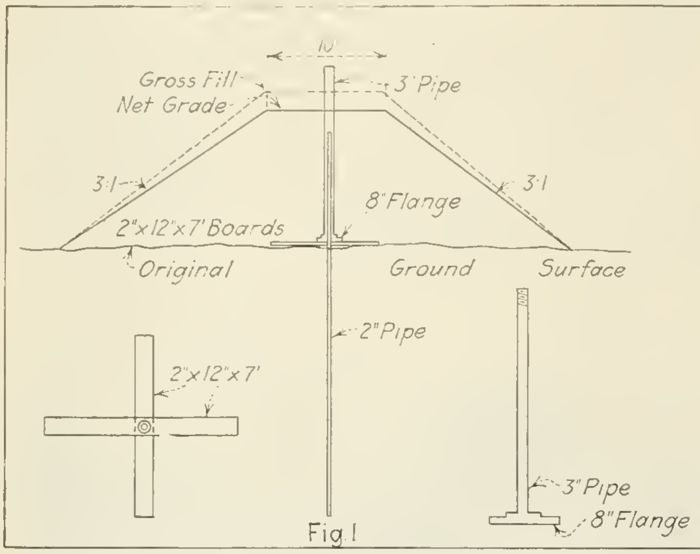


Fig 1

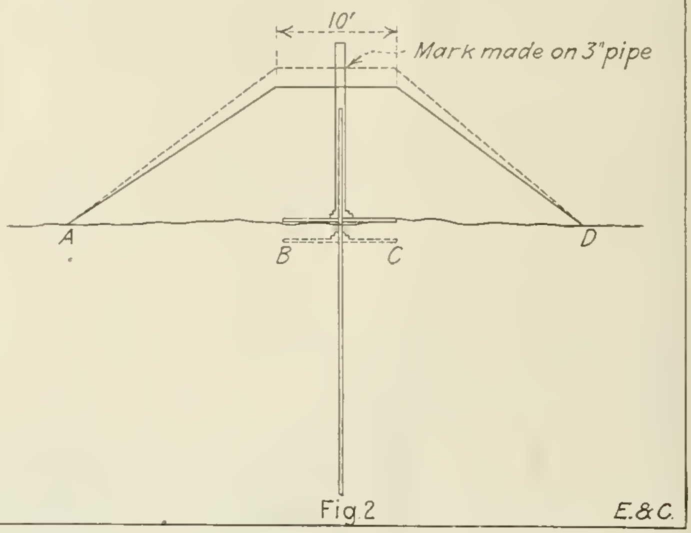


Fig 2

On the rear protection levee as being built the 2-in. pipes are 20 to 25 ft. long, being threaded at one end to permit lengthening the pipe when necessary. The 3-in. pipes are 12 ft. long and are threaded at both ends. One end screws in the 8-in. flange and the other end is lengthened when necessary, or fitted with a cap to prevent dirt from getting in. On this particular levee the humus strata varies from 5 ft. to 12 ft. in depth.

First, the 2-in. pipe is driven, as shown in the sketch, until sufficient penetration is secured, through good solid earth, so that pipe cannot be disturbed by the superimposed weight. The top of this pipe serves as a bench mark.

Two pieces of boards 2 in. x 12 in. x 7 ft. are spiked together as shown. The 8-in. flange is fastened with four lag screws. Into this flange is screwed the 3-in. pipe, the top of the pipe being fitted with a cap. The above is then slipped over the 2-in. pipe so that the boards lay flat upon the original ground surface. The elevation of the top of this 3-in. pipe is then taken.

The levee is then built to the grade and section as prescribed. On the rear levees it is not always possible to build to the prescribed grade in one lift. However, the height that the embankment is built to is marked on the 3-in. pipe. For illustration, it will be considered as built to gross height in one lift, and the 3-in. pipe marked as shown in Fig. 2. The elevation of the top of the 3-in. pipe and the elevation of the mark is taken. The difference in elevation between the original and final levels of the top of the 3-in. pipe gives the amount of subsidence. The comparison in elevation between the mark on the pipe and the elevation of the earth, when taken, gives the shrinkage.

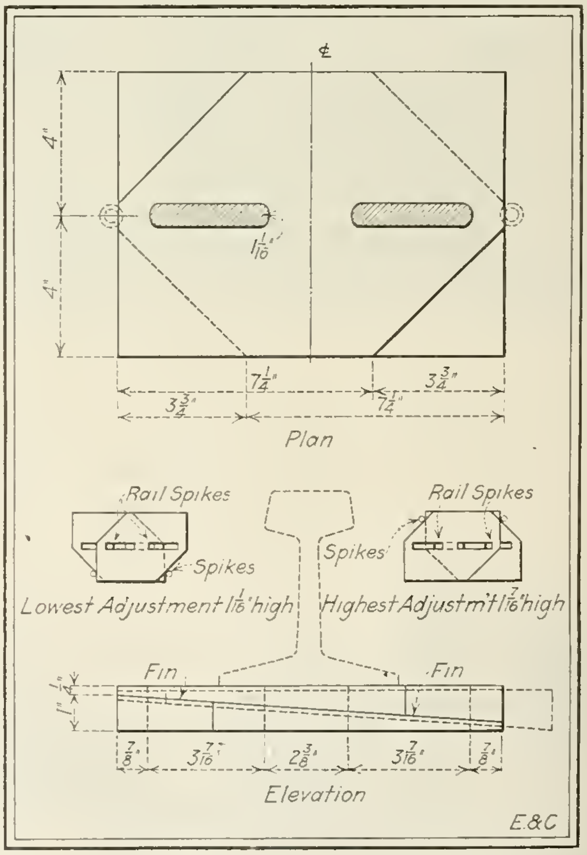
For illustration, if the top of the 3-in. pipe when set was 36.0 and the top of the embankment 35.0 and the final elevations of the top of the 3-in. pipe 34.0 and the top of the embankment 34.5, then the subsidence would be 2.0 ft. and the shrinkage 0 5 ft. The object in marking the pipe is to determine the relative conditions of shrinkage and subsidence after the embankment is built.

In paying for subsidence the area A B C D A (Fig. 2) is the area paid for, B O and C O being the subsidence as measured. If the shrinkage is above the estimated amount the contractor is paid for the additional work at the contract price.

C. T. Rayner, Jr., is Chief Engineer of the Commissioners of the Orleans Levee District.

## ARRANGEMENT FOR VARYING LEVEL OF RAIL AT TURNTABLE.

For some years the Atchison, Topeka & Santa Fe has been using wedge shaped tie plates for supporting the rails for carrying traveling cranes in its machine shops and roundhouses. Recently this type of plate has been employed for supporting the circle rail on the 100-ft. turntables of the company. The sketch shows the arrangement adopted for the new turntable at Albuquerque, N. Mex. The tie plates allow of a variation both of the position and of the level of the rail. The lowest adjustment is 1 1 10 in. high and the highest adjustment is 1 7/10 in. high. The adjustment is made by driving the upper plate forward or back and when the required elevation is secured it is maintained by a pair of screw spikes against the plate. The plates are 8x11 in. in size, with a thickness of 1 in. at one end and ¼ in. at the other. A pair of these wedge shaped plates are placed on each tie, the rail spikes being driven through the slots in the plates. The arrangement was devised by Mr. A. F. Robinson, Bridge Engineer of the Athison, Topeka & Santa Fe Ry.



Tie Plate for Adjusting Rail Heights.

Buildings and Structural Monthly Issue
of
# Engineering and Contracting
Halbert P. Gillette, *President and Editor*

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## EDUCATIONAL ADVERTISING AND ITS INFLUENCE ON BUILDING.

"Ignorance is the greatest obstacle to industrial progress. Advertising is a dynamite that has been most effective in blasting ignorance away."

With this as his text the editor of Engineering and Contracting recently addressed the Pittsburgh Advertising Club in a talk on "Educational Advertising." Educational advertising was defined as being the sort of publicity that is intended primarily to teach the economics of a given type of product or machine rather than to effect an immediate sale of a particular product or machine.

There are thousands of contractors using horses or mules for hauling loads that can be more economically hauled with motor trucks or tractors. Educational advertising is working a rapid change in the field of transportation over roads, as everyone is aware. It is true that engineering journals are primarily responsible for the publication of most of the reliable cost data relative to motor trucking, but it is not the province of the engineering journal to reprint the very same data again and again. Yet only by constant iteration and reiteration are all the readers made to realize that a given fact is worthy of their serious consideration. This reiteration of economic facts is the true function of the advertiser, and when he does it properly and truthfully his work is educational advertising.

More and more has advertising come to be truthful. Let it become more instructive—more educational—and we shall have ideal advertising.

At the great convention of advertising men in Philadelphia last summer the editor was impressed with the fact that "truth in publicity" is now the slogan of the army of men who conduct advertising campaigns. But the editor was sorry not to see equal emphasis laid on the greater use of economic data in advertising. This, however, will soon come. Already many advertisers are setting forth costs and giving hints as to the best ways of using their products under given conditions. Some catalogs, for example, are veritable text books, full of exceedingly useful information. The advertising pages of journals contain suggestive photographs and text, and, while there is much room for improvement, the march is steadily and rapidly onward toward ideal educational advertising.

In the building field certain manufacturers—big men of far vision—have been conducting publicity campaigns of educational nature. We wonder whether many of our structural engineering and contracting readers who are designers or builders of reinforced concrete, steel and other fireproof buildings, realize to what extent they are indebted to the advertising that these manufacturers have done. When you see the nation wide exploitation of cement, tile and reinforced concrete structures, when you read the advertisements of modern plumbing, heating and ventilating apparatus; when you note the publicity given to fireproofing, both by manufacturers and fire insurance companies, it will be well if you divest yourself of the common ideas that all this advertising effects merely a profit for the advertisers. If it is successful advertising it must be truthful. If it is truthful it must win purchases because it benefits the purchaser. If it benefits the purchaser it undoubtedly does as much good for the public as it does for the advertiser. Indeed it is safe to say that for every dollar expended in advertising, the public gains many dollars in efficiency.

If we recall aright Mill's "Logic," in the chapter on "Fallacies," states that a common sophism is the one that argues against accepting the advice of a person who profits if you accept his statements. A bargain that is a good bargain is always profitable to both parties to the transaction. You, as a reader profit by subscribing for this journal, and the publisher profits from your subscription. Indeed all co-operative effort is collectively profitable, and the bargains between two parties are merely devices for splitting up and sharing the gain resulting from co-operative effort. Let those who doubt it, go back to old Adam Smith's "Wealth of Nations"—that still admirable treatise on political economics—and read his analysis of the mutual gains from fair bargaining and co-operative effort.

Occasionally some thoughtless engineer speaks slurringly of the advertising pages of engineering papers, seemingly regarding them as akin to the "balleyhoo" shouting in front of the tents of a circus. But such engineers are relatively few, and their number grows daily less, for it is plain to be seen that advertising is an educational force, growing steadily more powerful.

The socialists have it that all advertising is waste effort that would be done away with if competition were eliminated. But they do not tell us how the elimination of competition will also eliminate ignorance. Education, they must grant, would remain necessary under socialistic rule. The best advertising is educational and will never cease.

Every cradle is a tiny kingdom of ignorance, and, as the kingdom grows, the boundaries of ignorance are pushed back only a little at best, even in the three score years and ten of allotted life. Parents, school, books, papers, publicity—all are mobilized in the effort to drive the encircling ignorance back from the individual mind, yet never with more than a modicum of success, for total knowledge must always remain vaster by far than the knowledge encompassed by any individual. Educational advertising, then, must remain as it now is, among the most effective means of enlightenment.

Listen, in conclusion, to the following quotation from a recent editorial by Mr. S. M. Fechheimer, B. C. E., in "Modern Building":

> The past decade has seen more changes and development in methods of building than any of the preceding ages. All types of buildings—houses, offices, stores, factories, etc.—show evidences of these modern improvements. What were considered "new fangled" ideas yesterday have become necessities today. Questions of convenience, sanitation and comfort have become so important that it is almost literally true, as said by another, that "The good American mechanic would not be satisfied to live in one of the old-time castles, at least unless modern heating, lighting and plumbing were installed."
>
> The average American accepts all these improvements as a matter of course and wonders at the high cost of building. He does not stop to consider that the modern tile bath room, for instance, which he now considers a necessity was the height of luxury a few years ago. Indeed, the owner today gets more for his money in the way of solid comfort and practical usefulness than he ever did in the old days, when labor and materials were cheap and partitions were uselessly built 2 ft. thick.
>
> Much less do persons realize one of the principal underlying causes for the rapid advance in building methods. Just as in the spread of knowledge generally, so here the development of the printing press has played an important part. But for the power of the press in spreading information quickly, we would be dwelling largely, in the old style of buildings. In our ignorance we would still be content with tin bath tubs, oil lamps, and stove heating. Everywhere—in the workshop and in the home—is seen the influence of publicity on

building. How else, except by publicity, would it have been possible to bring the advantages of reinforced concrete before builders? In less than a decade this construction has developed from a novelty to the standard fireproof construction. The leaders in this field did not hesitate to use the forces of publicity in their sincere efforts to place valuable information in the hands of architects, engineers, contractors and owners.

In the equipment of buildings, publicity has played the same important part. Manufacturers did not hesitate to use it to show improved methods in plumbing, heating, lighting, painting, etc. Think back in your own experience; was it not in the advertising pages where you received your first impressions in regard to many of the details you incorporated in your building?

Few of the public or of the building world realize the service which progressive manufacturers thus have rendered in influencing better methods of building. Courageously and unhesitatingly these men have borne the expense of important educational work, deriving for themselves only those incidental benefits that come from the use of better methods. It has taken big men with big ideas to do work of this kind and it is no wonder that many of them have developed big organizations.

When the whole story of modern building is written, you will find an important place is occupied by these broad gaged manufacturers who have unsparingly used the forces of publicity in bringing their improved methods before prospective builders. Their influence, more than any other single factor, is responsible for the high class of our modern building construction.

## DID AN UNDERESTIMATE OF A COEFFICIENT OF FRICTION CAUSE THE QUEBEC BRIDGE DISASTER?

We raised this question in our issue of Sept. 27 and as yet no engineer has attempted to refute our affirmative answer to it. One of our readers has asked whether we are certain that in designing the rocker joint castings (one of which broke and caused the Quebec Bridge disaster) a coefficient of sliding friction of only 10 per cent was assumed. Our authority for this is Mr. A. J. Meyers, Chief Draftsman, Board of Engineers, Quebec Bridge, whom we quote:

> The arrangement of castings and pins shown [the universal or rocker joint underneath each corner of the span] was demanded by the conditions of hoisting to place in the bridge. However, to take care of this expansion and contraction, the lower longitudinal pin and its bearing casting were polished and lubricated to insure that the friction would not exceed 10 per cent of the vertical end reaction of the trusses as the surface slipped under the end thrusts of the span; and the end bents in addition to taking care of the longitudinal wind on the span were designed to resist this horizontal friction force, which was estimated at 300,000 lb.—Eng. News, Sept. 14, 1916.

When we read this statement we were struck with doubt as to the correctness of an assumed coefficient of friction of only 10 per cent where the unit pressure is so great as existed in this case. As stated in our issue of Sept. 27 the unit pressure was not less than 5,360 lb. per square inch, assuming it to be uniformly distributed over the projected area of the longitudinal pin along which sliding was to take place in the event of temperature variations. We also stated that we could find no tests on coefficients of starting friction of journals or pins where the unit pressure exceeded 1,000 lb. per square inch. Nearly all mechanical engineers and some civil engineers know that the coefficient of starting friction is not a constant but increases with increased unit pressure. Yet here was a design of an important part of the equipment used in hoisting this huge span apparently based on two assumptions of questionable accuracy: First, that the coefficient of starting friction at a unit pressure of more than 5,000 lb. per square inch would be as low as at a few hundred pounds per square inch. Second, that a low temperature would not considerably reduce the coefficient of friction of the lubricated pin bearing.

Thurston's tests on steel journals in bronze bearings, lubricated with sperm oil, indicated that up to pressures of 1,000 lbs. per square inch the following formula applies:

$f = 0.015 \text{ to } 0.02 \sqrt[3]{p}.$
$f$ = coefficient of starting friction.
$p$ = pressure in lbs. per sq. in.

The coefficient of starting friction increases as the cube root of the unit pressure up to 1,000 lb. per square inch. Who knows what the increase is up to 5,000 lb. per square inch? But assuming it to increase at this rate up to 5,000 lb. per square inch, we deduce from this formula that the coefficient of starting friction with sperm oil lubrication would be as high as 34 per cent!

It is obvious that if the coefficient of friction actually approximated 34 per cent, whereas the design of the rocker joint was based upon an assumed 10 per cent, the horizontal thrust upon the casting, resulting from a temperature change, was in itself sufficient to account for its failure.

It should also be noted that the coefficient of friction is a function of the temperature of the lubricant, the coefficient varying inversely with the temperature. There are, of course, several other variables that affect the frictional resistance, all tending to cast grave doubt on the accuracy of the assumed 10 per cent. Who knows, for example, to what extent a lubricant is squeezed out of a pin bearing after a few days' service? The lubricant need only leave the bearing in slight measure to cause a marked rise in the frictional resistance.

The fact that the breaking of one of the rocker joint castings threw a double load on another rocker joint without breaking it, is cited as proof that the rocker joints were properly designed but that there was a defect in a steel casting in the joint that broke. This is by no means convincing argument even for vertical loading, and it is no argument at all if a horizontal thrust was the cause of the break, as we believe it was.

It is not often that the structural engineer finds that a correct coefficient of friction is a factor of vital importance. Perhaps this accounts for the fact that relatively few structural engineers are well acquainted with all the important test data relative to friction. Such disasters as the recent Quebec Bridge failure and Austin Dam failure should serve to focus attention upon the somewhat neglected coefficient of starting friction, particularly under great pressures.

## THE ADVANTAGES OF CO-PARTNERSHIP BETWEEN ENGINEERS AND ARCHITECTS.

A partnership between a structural engineer and an architect often proves an ideal union of the economist and the artist. Recently the personal columns of civil engineering journals have recorded an increasing number of such partnerships. We venture the prediction that each coming year will witness a marked increase in engineering-architectural co-partnerships.

There are many new forces at work that tend to develop relationships of this sort. To begin with, the increasing wealth of the country leads inevitably toward the construction of larger and better buildings of all sorts. The financial progress of every nation is always marked by the betterment of both residential and industrial buildings. With larger investments in buildings there comes greater care in selecting the designers. And when an owner gives careful thought to this matter, it takes no unusual powers of perception to recognize that it pays to employ a designer skilled in study of building economics—structural engineering.

As observed in another column, educational publicity is playing an important part in convincing owners that it pays to build for permanence. When to the publicity effected by manufacturers of cement, tile, steel, etc., there shall be added the publicity that individual engineers and structural engineering societies can effect, owners will more commonly demand engineering services of high order in the designing of buildings. We believe that this demand will not relate to industrial buildings only but will involve residential buildings. Take, for example, the problem of heating a house. Here is an engineering problem of no mean intricacy, yet, as conditions now exist, its solution is usually left to the mechanic who installs the heating apparatus. How many house owners know that the efficiency of the average furnace is less than 50 per cent and that it could be raised to 75 per cent? How many know that the heat lost through the window glass constitutes the greatest drain upon their coal bin, and that double glazing cuts this drain in two? How many know that cheap and defective plumbing not only doubles their annual maintenance costs but results in a vast waste of water which, directly or indirectly, they must pay for? How many know that, for equal illumination, light colored interior walls decrease the monthly lighting bills as compared with dark walls? How many realize that white exterior walls in courts and where buildings are close together will eliminate at least one hour of artificial illumination daily? How many know that by building large refrigerators as part of the house they can not only cut ice bills in two but reduce the cost of all perishable foods by buying in larger quantities?

We have touched but a few of many economies of household operation that are effected by the design of the house, yet they alone would justify employing an engineer in the design of every modern residence.

We believe that an engineer who specializes in household economics both of operation and construction has a better chance of winning clients than has an architect. Together a good structural engineer and a good architect should easily forge ahead of any firm composed only of architects.

## A NATIONAL SOCIETY OF STRUCTURAL ENGINEERS.

Evidence multiplies that archiects have been for years striving to exclude structural engineers from the building field. When the engineers of Illinois started out to get a state law that would put structural engineers on equal footing with architects, at least in respect of authority to design commercial buildings, they were met by an architects' lobby that came within an ace of defeating their effort. The structural engineers' license law of Illinois, printed in full on another page, is, to some extent "a thing of shreds and patches" simply because many compromises had to be accepted rather than witness the defeat of the bill.

We wonder how many structural engineers in other states realize the extent to which the architects have hemmed them in. Let it not be assumed that a mere reading of an architect license law tells the whole tale. After securing a state law that requires architects to "register," the next step has often been to secure the passage of city ordinances prohibiting the acceptance of plans filed with the building department unless indorsed by a "registered architect."

Not long ago an architect advertised for a structural engineering assistant. Asked why he did not advertise for a structural engineer as a partner, he replied: "Our society frowns upon any such association. Architects believe in keeping the engineer in his place."

Structural engineers have ideas as to their "place" that differs quite a bit from the ideas of most architects. Individually, however, engineers will make slow headway against the organized opposition of architects. This is the primary reason why every state should have its association of structural engineers, eventually to act in national unison upon all matters concerning their welfare.

Beyond this reason for a national society of structural engineers there are two others: First, a strong national society could give great publicity to the part played by the structural engineer in the design of industrial buildings. This alone warrants the existence of such a society. Second, the problems of the structural engineer are so many and so complex that a separate engineering society is needed for their adequate consideration.

It is commonly urged that there are enough societies already, and that what is now needed is a federation of these that already exist. We grant that such a federation is greatly to be desired, but we maintain that an autonomous society of structural engineers is, nevertheless, a great desideratum.

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If all city streets were properly paved, it would be possible to wash them clean at night, and thus reduce disease to say nothing of increasing the comfort of all "within the city gates."

## STRENGTH OF CLAMPED SPLICES IN CONCRETE REINFORCEMENT BARS.

To the Editor: I have read Mr. McCullough's letter to your paper in regard to the strength of Clamped Splices in Reinforcement Bars and judge he fears that the statement made by E. L. Lasier in a paper before the American Society of Testing Materials that "clamped lap splices embedded in large masses of concrete undoubtedly can safely withstand a unit load equal to the unit stresses in steel reinforcement" is going to lead to a great number of disasters if contractors should continue to use this method of splicing reinforcement bars.

Mr. McCullough speaks so positively of the inefficiency of the clips for splicing reinforcement bars, that the writer is curious to know the method used in the experiments on which he bases his sweeping condemnation. It is just as unfair to condemn all clips because one or two kinds failed as it would be to discourage the use of concrete for building purposes because now and then a building fails in course of construction. Mr. McCullough's experience has been so different from the writer's in recent experiments with Crosby Clips that he believes that Mr. McCullough and all engineers and contractors will be interested in hearing about them. These tests conclusively show that results have been obtained from clamped splices showing a greater factor of safety at the point of slip than advocated by him as good engineering practice.

Fifteen tests were made, using three sizes of cold twisted square bars, ½ in., ¾ in. and 1 in. Two clips suitable for the size of bar were used in each test placed on the bars as shown in the accompanying sketch and Table I:

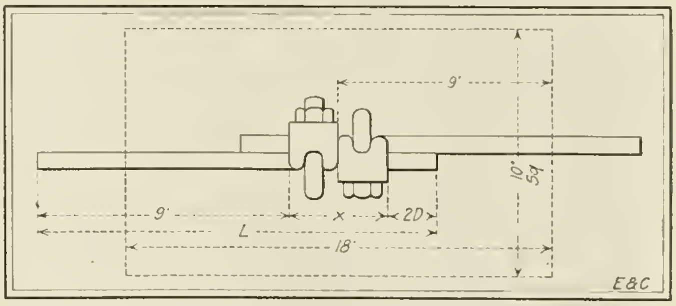


TABLE I.

| Size bar. | 2D. | X. | L. | Length of wrench used. |
|---|---|---|---|---|
| ½-in. ........................ | 1-in. | 3¾ | 13¾ | 12 |
| ¾-in. ........................ | 1½-in. | 5½ | 16 | 18 |
| 1 -in. ........................ | 2-in. | 6 | 17 | 21 |

All clips were tightened with wrenches having handle length recommended by the manufacturer of the clip.

The concrete was a mixture of 1-2-1 made under rather unfavorable conditions during the months of January and February. It was cast into blocks 18 in. long and 10 in. square.

The tests were made on an Olsen Testing Machine of 100,000 lb. capacity. Two men conducted the tests, one operating the beam and the other observing the point of slipping.

The limit of travel of the machine due to the size of the blocks prevented as high a final load reading, in some cases, as might have been obtained with a longer travel as the beam was still rising when the limit of travel was reached.

Before placing the block in the testing machine a cast iron jacket was bolted around the four sides of the block to prevent as far as possible pieces of concrete which might be broken from the block from falling on the operator or the machine.

Prick punch marks were placed on the rods at each end of the block and around the punch mark; at the upper end the rod was file finished and coppered with a copperas solution.

After placing the block in the machine dividers were set to the punch marks and a scratch made on the coppered surface. Any elongation of the distance between the two punch marks was plainly noticed as soon as it occurred. Due to the eccentricity of the pull on the two bars a slight movement from this line was noted on some of the tests until the pull came into line when a new scratch mark was made. The straightening action was very apparent by the tilting of the block.

In many cases no apparent dropping of the load was noted at the point of slip, but the beam continued to climb until the final load was reached.

The results obtained are given in Table II.

The builders have declared that they will re-erect the suspended span in exactly the same manner as before. The prediction is here recorded that they will not. I predicted that in the second erection the erection gantry would be braced. It was well braced in every direction, and not at all like the first one. After reading the following explanation of the failure, here or elsewhere, they will revise their determination.

TABLE II.

| Kind of rod. | No. of tests. | Point of slip or stretch. Lbs. per sq. in. | Final load. Lbs. per sq. in. | Factor of safety at point of slip. At 1,600 Lbs. per sq. in. | Remarks. |
|---|---|---|---|---|---|
| ½ in. sq., twisted.............. | 5 | Max. 72,000 | Max. 76,000 | 4.5 | Yield point, 65,000 lbs. |
| | | Min. 48,000 | Min. 69,500 | 3 | 4 rods broke, aver. 74,100 lbs. per sq. in. |
| | | Aver. 65,580 | Aver. 74,080 | 4.1 | |
| ¾ in. sq., twisted.............. | 5 | Max. 60,100 | Max. 74,300 | 3.76 | Yield point, 58,000 lbs. per sq. in. |
| | | Min. 52,400 | Min. 65,700 | 3.28 | 1 rod broke, aver. 74,300 lbs. per sq. in. |
| | | Aver. 57,380 | Aver. 69,520 | 3.58 | |
| 1 in. sq., twisted.............. | | Max. 53,000 | Max. 66,000 | 3.3 | |
| | 5 | Min. 29,000 | Min. 57,900 | 2.44 | Yield point, 57,000 lbs. per sq. in. |
| | | Aver. 48,400 | Aver. 63,440 | 3.1 | |

From the above results I cannot see why any engineer should not feel safe in using clamps of a design which will show in a series of tests a minimum point of slip not less than 2.44 times an allowable fibre stress in reinforcement of 16,000 lb. per square inch.

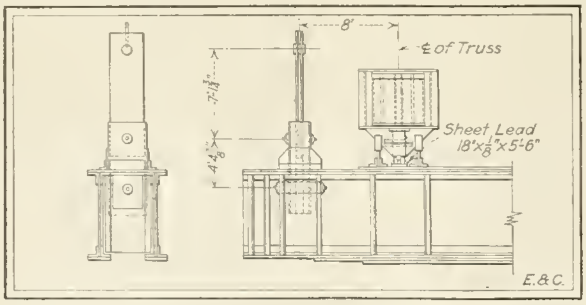
Very truly yours,
Carl A. Herrick.

3816 Thomas Ave., S.
Minneapolis, Minn.

## THE QUEBEC BRIDGE DISASTER.

To the Editor: When the Quebec Bridge fell in 1907, the plain truth that it was pulled over by the great erection gantry was so exasperating that in 8 lb. of printed matter, which constituted the Royal Commission's Report, there is not the flicker of a hint in any question that was asked or any statement that was made that bore on the possibility of this unbraced gantry having been the cause of the collapse. This in spite of the fact that in a letter published a few weeks after the collapse I pointed out that it was the neglect of one of the simplest principles of equilibrium that brought down the great structure.

The lack of bracing in the great traveler or gantry by which the first structure was being erected was responsible for its fall. I attempted, 14 months before the collapse to warn the builders, by sending a letter to an engineering paper, but the paper refused to publish my letter. If the reader will just imagine a structure as large as a good-sized 16-story office building, with 1,000,000 lb. of steel on top of it, and this structure totally lacking in bracing between two high bents at the sides, he will have a good idea as to what destroyed the first Quebec Bridge.



If he will imagine himself sitting on the seat of a swing and trying to balance without holding on to the ropes, he will have an idea as to what it was that dropped the second Quebec Bridge. Or, if he will take a paint can and swing the bale just half way down the side of the can instead of near the top, and balance something across the top of the can, and then attempt to carry it by the bale, he will have a still more accurate idea of the cause of this failure.

Neglect of one of the simplest principles of equilibrium is the sum and substance of the thing, and it can all be demonstrated in three minutes.

The above figure shows one of the girders upon which the four shoes of the suspended span were raised. These short girders were hung on chains of bars. The last pin in the chain was just above the top of the girder. The girder could therefore rock or swing around this pin. The astounding thing about the design is that the pin of the shoe supporting the big span was almost in line with these suspending pins. It was a trifle lower, but the published details do not show just how much.

Suppose the shoe pin had been on the same level as the last pin of the suspending chain. It would have been impossible to raise the span a foot. The girder would simply have flopped over and dropped the shoe and its load.

Suppose the shoe pin had been 3 in. lower than the pins of the suspending chain and suppose the shoe were one-twentieth of this or 0.15 in. off the center of the girder. This would tilt the girder enough to give it a slope of 1 in 20. If the coefficient of friction were one-twentieth between the greased surface of the longitudinal pin and the casting above it, this would give just the force to slide the shoe off the girder and into the river. If the coefficient of friction is more than that assumed, or if the vertical distance were more, it just means that the shoe would have to be somewhat more than ⅛ in. out of place, which it could very readily have been.

The thing was in unstable equilibrium any way you look at it, and the only marvel is that it did not drop before it was raised even 15 ft.

The idea that the breaking of a steel casting caused the failure is untenable. The casting no doubt broke. Something had to break, but the failure was due to the overlooking of a very simple principle of equilibrium.

Yours truly,
Edward Godfrey.

Monongahela Bank Bldg., Pittsburgh, Pa.
Sept. 30, 1916.

Since writing the above more details have been published, also some arguments aiming to show that it was not the instability of the supports that caused the failure but the breaking of shoe castings.

It has been brought out that the vertical distance between the last pin of the supporting chain and the shoe pin was only 2¾ in. It is astounding that this should be the case, that even a condition of unstable equilibrium should depend upon these shoes being placed and maintained within less than ⅛ in. of the exact center of these large supporting girders. It is taking unheard-of chances with fate to create a condition demanding such accuracy, especially when there exists no reason whatever for so doing.

Another published fact is that the longitudinal pin on which the middle shoes slid was not only well greased but was polished. Here is another ideal condition for just such occurrence as that which took place. A very small slant to the girder was enough to cause the shoe on this greased and polished pin to slip off in toboggan style and drop its load into the river. The coefficient of friction on such surfaces is very small.

The statement has been published that the girder would have to rock nearly 90° for the shoe to slip off and evidence shows that no such rocking took place. It is far from true that the shoe would have to rock through any greater angle than that whose tangent is 1/20, or whatever is the coefficient of friction of polished and greased surfaces on each other. The girder would be shot out in a horizontal direction and made to swing away while the span dropped. That it did this is shown clearly by the photograph taken while the span is dropping, for the girder is swung out in exactly this manner.

It is also publicly stated that there were centering plates that would hold the middle shoe from sliding on the lower pin. These plates, against the tremendous force of 2,600,000 lb. sliding down an incline, would have exactly the chance of the proverbial wax rabbit in hades. They were wide thin plates bearing on the thin edge at the corner on a chipped surface. No structural engineer will claim that they are in any sense an adequate detail where forces of this magnitude are concerned.

It is hardly to be expected that a shoe of this size could be located on a large built girder with such extreme accuracy. Another phase of this required precision would develop when the span was near the top. The distance center to center of supports at the cantilever arms could not be within an eighth of an inch in accuracy. The swinging arm should have been several feet instead of 2¾ in.

The breaking of one or more of the middle shoes is readily explained. After the girder had rocked through a very small angle the shoulders of the upper and middle shoe would come together. Instead of stopping the rotation the pressure would be so enormous that one or the other of the shoes would simply be crushed. Imagine a pressure of 2,600,000 lb. on a line a little over 2 ft. long. The shoulders were ¾ in. wide but would not meet squarely. Even assuming a surface 24x¾ subject to this pressure of 144,000 lb. per sq. in., crushing and facture would be the necessary accompaniment. The middle shoe doubtless broke with the loud report heard, after the rotation had crushed it. This was a mere incident in the failure and in no sense a cause. It is not the fault of the material. No material ever made could stand such forces.

Every great structural failure that ever took place was the fault either of the design of the structure or the plan of its method of erection.

Yours truly,
Edward Godfrey.

Oct. 18, 1916.

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## COST OF FORM WORK FOR VARIOUS TYPES OF FLOORS.

The following costs on form work are given by H. Whittemore Brown, assistant, Testing Material Laboratory, Massachusetts Institute of Technology, in a paper presented on Oct. 12 before the Boston Society of Civil Engineers: In a recent example of groined arch construction in reservoir roofs wooden forms were used, being made up in convenient sections at a woodworking mill and transported to the job at an initial cost of about 20 ct. per square foot. Having them carefully built enabled them to be used 7 or 8 times with a minimum amount of work in removing and resetting, the total average cost per square foot of the entire roof being given by the contractors at 4½ ct. This work was in connection with the Springfield, Mass., water supply, the Charles R. Gow Co., Boston, Mass., being the contractors. The cost of form work for floors in the Carter's Ink Co. factory, a good example of beam and slab construction, was 11 ct. per square foot. The Aberthaw Construction Co. was the contractor. The cost in the Winchester Repeating Arms Co. factory, a typical mushroom or flat slab construction, was reported at 12½ ct. per square foot.

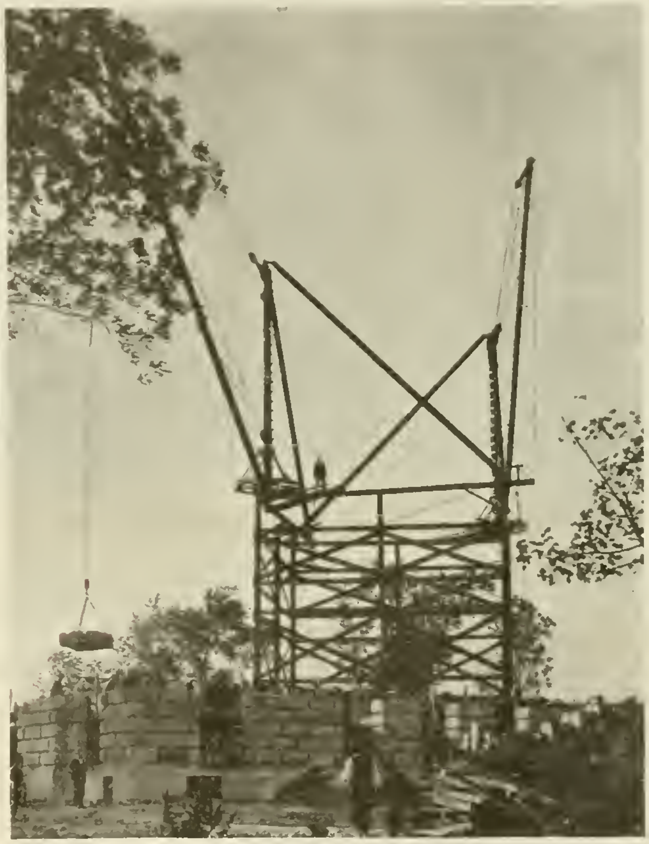
## ERECTION METHODS FOR BOONE COUNTY, IA., COURTHOUSE.

The use of a 52-ft. tower and stiff leg derricks is enabling the contractor for the $200,000 court house at Boone, Ia., to make rapid progress in the erection of the structure.

The building will be 81 ft. by 146 ft. 10 in., four stories and basement. The walls will be faced with granite for the two base courses and with Bedford limestone above, all backed with hard burned shale brick. All floors and roof will be of reinforced concrete and hollow tile. The derricks used on the job consist of two 5-ton stiff leg, placed on a tower 38 ft. by 38 ft. by 52 ft. high. This tower is made up,with 10 in. by 10 in. posts, 3 in. by 10 in. braces and 10 in. by 10 in. sills and plates. The following information applies to each derrick:

| | |
|---|---|
| Mast | 12 in. by 12 in.—36 ft. long |
| Boom | 10 in. by 12 in.—70 ft. long |
| Stiff legs | 10 in. by 10 in. |
| Bull wheel | 12 ft. diameter |

The derricks were constructed of fir timbers with structural steel fittings which were furnished by the Minneapolis Steel Machinery Co. of Minneapolis, Minn. The framing was all done by union carpenters at the building site.



Tower and Derricks Used in Erecting Court House at Boone, Iowa.

The derricks are operated by an American hoisting engine 5½-in. by 8-in. double cylinders, double drum with boom swinging attachment.

The tower is placed approximately in the center of the building with derricks placed on opposite corners the long way of the building, so that each derrick covers one-half of the building. The braces are so placed as to clear the floors.

This design enables the outside wall to be carried story high on one end of the building at a time, thus permitting the concrete floor on that half to be poured while the walls on the other end are being carried up. By this method the stone masons, brick masons and carpenters can be kept busy practically all of the time and the concrete floors are given sufficient time to set before resuming the construction of the outside walls.

Norman T. Vorse, 911 S. & L. Bldg., Des Moines, Ia., is the architect. The Boyd Construction Co., 312 Germania Life Bldg., St. Paul, Minn., is the general contractor.

# DESIGN AND CONSTRUCTION OF THE UNIT-BUILT REINFORCED CONCRETE TRAIN SHEDS OF THE DENVER UNION STATION.

Contributed by Albert M. Wolf, Chicago, Ill.

The Denver Union Terminal Railway Co. has, since September, 1914, been making extensive improvements to the old Union Station at Denver, built in 1880. The reconstruction is being carried out by the company—the equal owners of which are the Union Pacific, Colorado & Southern, Denver & Rio Grande, Santa Fe, Burlington, and Rock Island railroads—to provide facilities commensurate with the volume of traffic handled. The Terminal Company controls the station only, owning no equipment of any kind, each road providing its own service other than that performed by the passenger station. The improvements, which were completed in July, 1916, represent an expenditure of about $3,800,000, and they include the complete reconstruction and enlargement of the track layout, the rebuilding of the main portion of the station, and the erection of about 6,700 lin. ft. of cantilever butterfly-type shed of pre-cast concrete units of unique design. This article will treat only of these sheds.

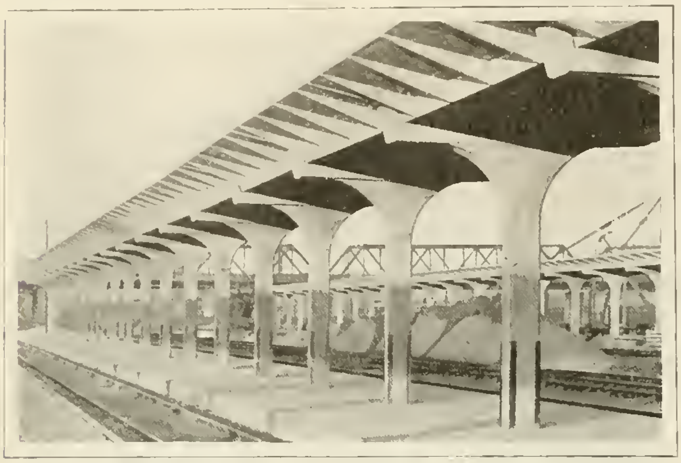
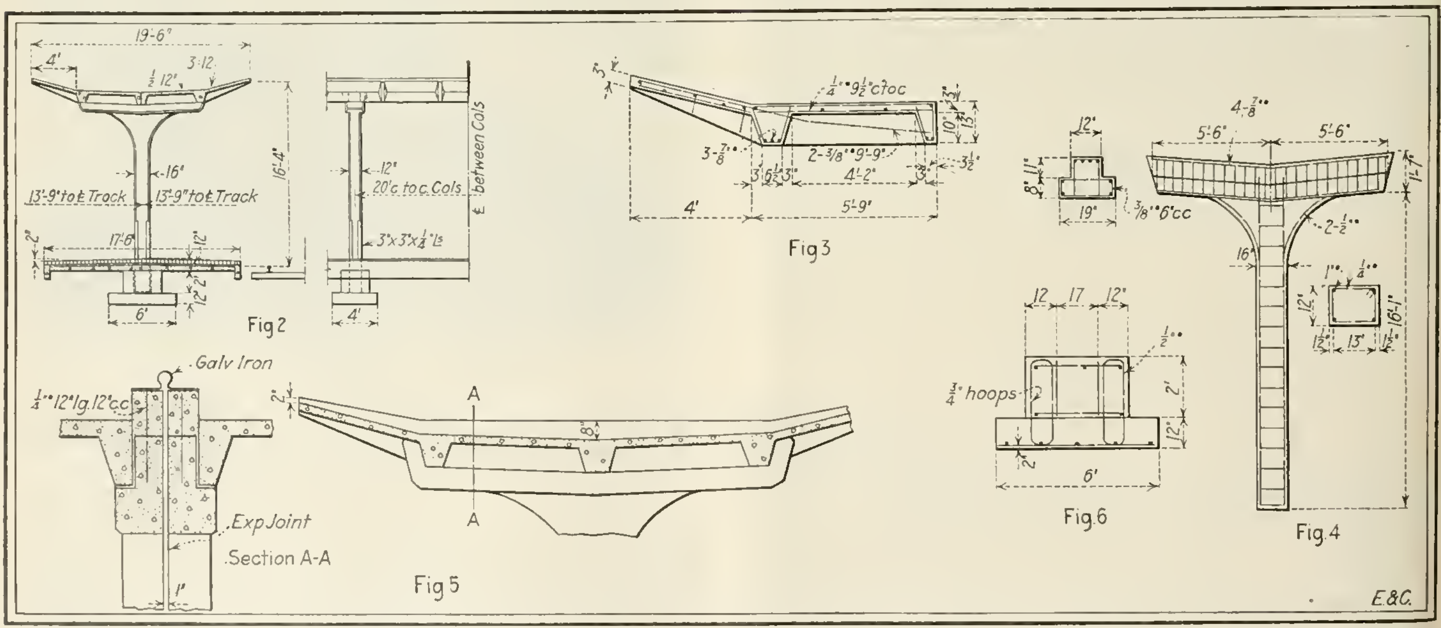


Fig. 1—Arrangement of Passenger Platform and Umbrella Shed.

**General Features.**—Due to the fact that trains enter from both the east and the west, the station—although a terminal—has a track layout of the through type, with the central portion of the yard approximately opposite the main portion of the station. To avoid interference of trucking with passenger traffic, the platforms are so arranged as to have each passenger platform and its umbrella shed serve two tracks, with an uncovered trucking platform between each two alternate tracks, as shown in Fig. 1. The passenger platforms are 17 ft. 6 in. wide, while the trucking platforms are 14 ft. wide, all of concrete construction, with lengths varying from 1,200 to 2,050 ft. Entrance to, and exit from, trains are made through 6-ft. stairways from the platforms to a passenger subway 25 ft. wide and 8 ft. high lined with white enameled brick, leading to the station concourse and exit. Baggage and express subways, one on each side of the passenger subway, near the ends of the platforms, are served by electric elevators at the platforms and also at the baggage and express rooms in the station building.

The umbrella sheds which cover the passenger platforms are of special interest. These sheds, five in number, cover platforms which serve ten tracks. They have a spread of 19 ft. 6 in. and a height above the top of rail at the outer end of the cantilever wing of 16 ft. 4 in. They consist of roof slab units 20 ft. long and 9 ft. 9 in. wide (two for each bay), carried on reinforced concrete beams cantilevered from reinforced concrete columns see Figs. 1 and 2). The footings for the columns were poured in place; while the column and roof slab units were cast in a central yard nearby, and after curing were erected by means of a locomotive crane. No roofing material was placed on the roof slabs, some hydrate of lime having been added to the concrete when mixing and the top surfaces troweled to a smooth, impervious finish. After completion, the roof surface was given a coat of waterproofing compound to prevent leakage at the joints and to insure the waterproofness of other parts.

The merits of unit-construction methods for reinforced concrete, as applied to certain types of structures involving considerable duplication of a few simple parts, has been recognized by engineers for some time, and in the umbrella shed for passenger station platforms there is found one of the most notable examples of the adaptability of unit methods. This type of shed is permanent and fireproof; it therefore requires no outlay for maintenance, and the cost, about $12 per linear foot, compares very favorably with similar sheds of steel frame construction with wood roofs.



Figs. 2-6—Details of Unit Reinforced Concrete Train Shed for Denver Union Station.

**Details and Methods of Design.**—From an inspection of Figs. 2 and 3 it will be seen that the roof slab units consist of a 3-in. slab, the inner portion of which, 5 ft. 9 in. wide, is reinforced transversely between two longitudinal beams and an outstanding or cantilever wing portion having a 4-ft. projection beyond the outer longitudinal beam, which is reinforced longitudinally between cantilever rib beams spaced 5 ft. on centers. These centilever beams are 4 in. deep at the ends and 13 in. deep at the connection, with the longitudinal beam; this section is carried over to the inside longitudinal beam to give added stiffness to the unit and anchorage for the reinforcement of the cantilever (see Fig. 3). To facilitate the removal of units from the forms all beams are given a bevel of 3 in. on both sides.

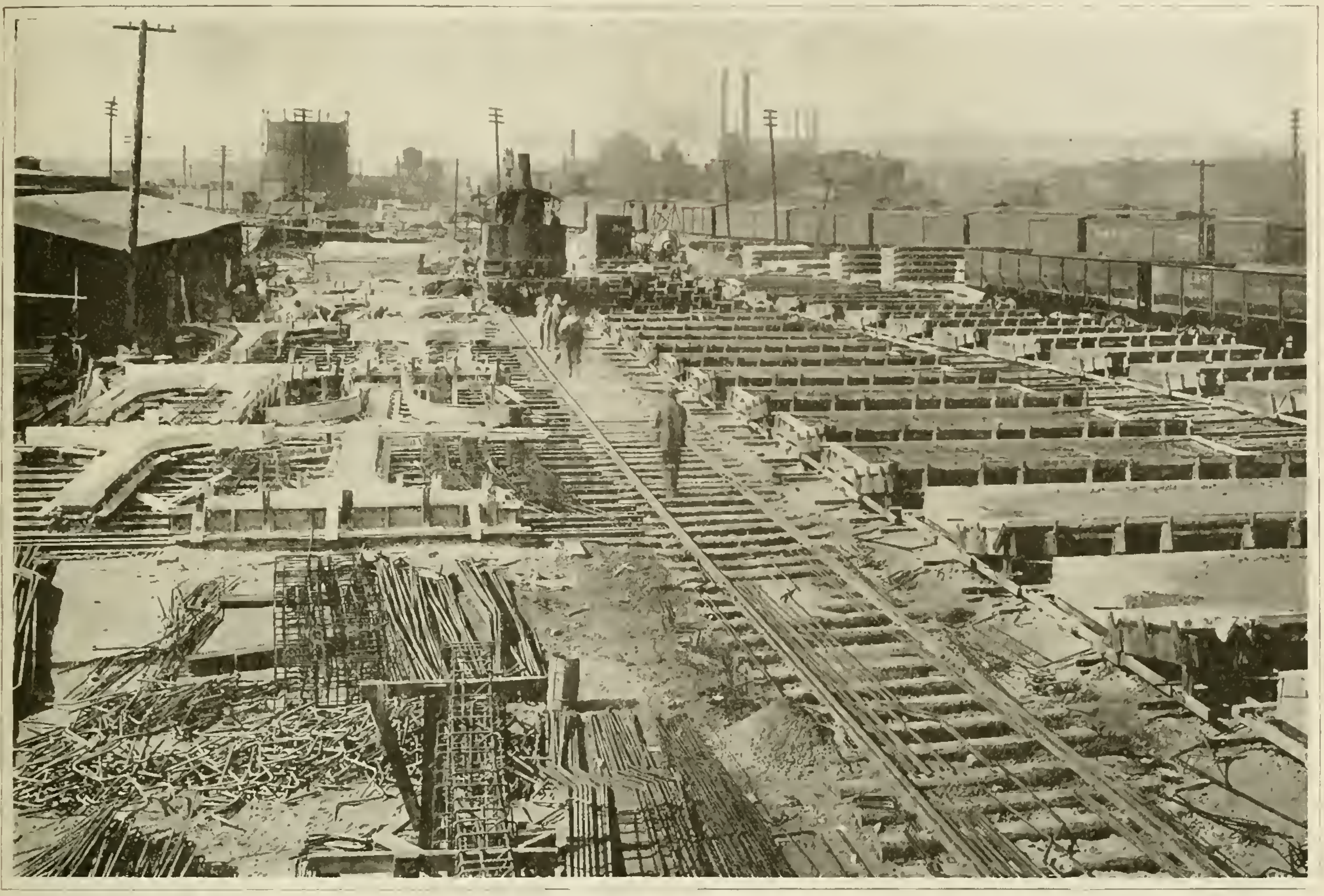


Fig. 7—General View of Casting Yard.

The roof slabs and beams were designed for a total load of 70 lb. per square foot, of which 32 lb. per square foot is live load. These numbers were considered as simply supported in designing. The allowable stresses were 650 lb. compression in the concrete and 16,000 lb. tension in the reinforcing steel.

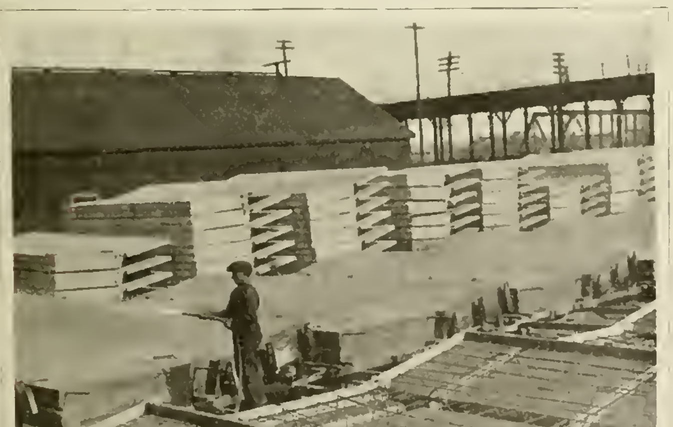


Fig. 8—Roof Slab Units in Various Stages cf Construction.

The design features of typical column units are sown in Fig. 4. These units consist of a 12x16-in. column with a cross beam to support the slab units, which are cast integral with the column. They have an overall length of 17 ft. 8 in. and weigh about 7,000 lb. each. The columns are reinforced with four 1-in. square bars tied together with $\frac{1}{4}$-in. diameter hoops spaced about 10 in. on centers. To protect the edges of column, a steel guard angle about 3 ft. 6 in. high is embedded in each corner. The cross beams are bracketed to the column with curved fillets, and are built in the shape of an inverted T-beam. They are 19 in. wide at the bottom and 12 in. wide at the top,

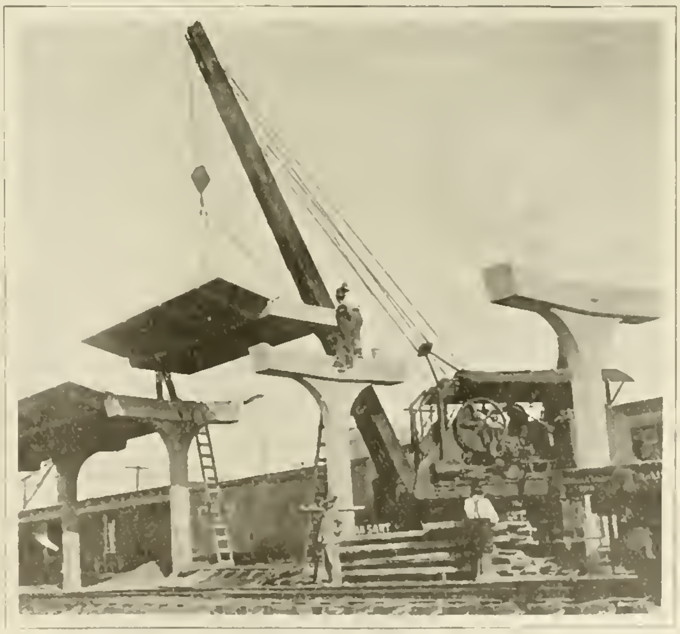


Fig. 9—Handling Roof Units.

the support for roof units being formed by $3\frac{1}{2}$-in. shelves 8-in. deep. The reinforcement of the beam consists of stirrups and straight bars, as is shown in Fig. 4. Over the stairways leading from passenger subway to the platform level the roof slabs are carried on bents consisting of two columns seated in side walls of the stairway and supporting a cross girder at the top, the inner fillets of the column forming an arch.

An interesting feature of the design is the manner of forming the expansion joints in the several sheds. These joints are spaced about 360 ft. apart, and are designed to relieve the structure of the accumulative effect of expansion and contraction. They are formed, as shown in Fig. 5, by placing two columns in one footing, with a 1-in. space between them. After placing the slab units on the column beams a concrete coping about 1 ft. high was added to each beam, and over the opening between them a piece of galvanized iron was placed, so bent as to allow movement of the parts connected.

The typical column footings are built in two courses, the lower course being 6x4x1 ft. deep and the top one 3 ft. 5 in. x 3 ft. 1 in. x 2 ft. deep (see Fig. 6). Considering the direct and wind loads the pressure on the soil under the footings is about 2,600 lb. per square foot. The footings were made oblong, instead of square, with the long dimension transverse. The top course of the footing is anchored to the lower course by $\frac{1}{2}$-in. square loops in each corner.

A 1:2:4 concrete was used throughout and all steel was protected by the following minimum thickness of concrete: Columns, $1\frac{1}{2}$ in.; beams, 2 in.; and slabs, 1 in. The unit stresses allowed were: Compression in concrete in cross bending, 600 lb.; tension in deformed bars having a minimum yieldpoint of 33,000 lb. per square inch, 16,000 lb.

**Construction Methods.**—As previously stated, the column and roof slab units were pre-molded. This work was done in a yard arranged especially for the purpose near the station. The forms for all units were erected on old rails set with an instrument to a uniform level. The accompanying view of the yard (Fig. 7) shows very clearly the different stages of the work, namely, the fabrication of the reinforcing, the column units in various stages of construction, the roof slab forms with reinforcement in place, the completed slabs, and also some slabs stacked in piles for curing. The mixer and locomotive crane used for distributing concrete and handling units are also shown in this view.

The beam boxes of the roof unit forms were lined with sheet metal. To prevent the sticking of forms to the concrete they were coated with paraffin oil before placing the reinforcement. In the foreground of Fig. 8 there can be seen a number of roof slab unit forms with the reinforcement in place ready to receive concrete and some recently cast units receiving their daily sprinkling before being removed from the form beds, while in the background there are stacks of completed units, piled up for seasoning.

To reduce the cost of framework to a minimum, the forms for all units were so designed that the side forms were entirely independent of the bottom forms and were capable of being removed as soon as practicable after pouring. By this method it was possible to get along with only about one-third the number of side forms as bottom forms, and in addition the finishing of the exposed surfaces was facilitated. After curing for at least one week the units were picked up by the locomotive crane and placed in stacks. Handling hooks, embedded in the cross beams near their ends, permitted the ready attachment of lifting cables. The electric conduits were placed in a space formed by longitudinal grooves in the inside longitudinal beams of each section, lights at the center of each bay being supplied from this conduit.

After a thorough seasoning in the casting yard the roof and column units were loaded on flat cars by the crane and hauled to the site. The columns for several bays were then placed, with the locomotive crane, their ends being set into the footing slot and grout poured in to anchor them. Until this grout had hardened the columns were braced together longitudinally, and were held plumb by means of a series of horizontal board struts. The roof units were hoisted as shown in Fig. 9 and set in a bed of grout on the supporting column cantilevers. To anchor these units to each other the rods projecting from the ends of units lap each other over the column beams, and the rods are covered with grout brought up level with the remainder of slab. The longitudinal joints between sections were carefully grouted to prevent leakage.

**Personnel.**—The sheds were designed and constructed under the supervision of the late H. W. Cowan, chief engineer of the Colorado & Southern, and his successor J. G. Gwyn, chief engineer of the Denver & Rio Grande, acting as chairman of the engineers' committee. This committee was composed of the chief engineers of the six companies owing the station property. The designs were made and the work carried out by the Van Sant-Houghton Co. of San Francisco and Denver, western representatives of the Unit Construction Co. of St. Louis, Mo., who control the use of unit construction under several patents. The writer is indebted to Shirley Houghton for plans, photographs and data used in this article.

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## STRUCTURAL ENGINEERS' LICENSE LAW OF THE STATE OF ILLINOIS.

On July 5, 1915, the Governor of Illinois approved the bill providing for the licensing of structural engineers in that state. Under the provisions of this law licensed structural engineers are exempt from the provisions of the 1897 act licensing architects and regulating the practice of architecture as a profession. The Illinois law contains so many excellent points that it is reprinted below in full, as a model that might well be followed by engineers in other states seeking relief from unjust restrictions imposed upon them by license laws drawn solely in the interest of the architect.

### AN ACT TO PROVIDE FOR THE LICENSING OF STRUCTURAL ENGINEERS.

Section 1. Be it enacted by the People of the State of Illinois, represented in the General Assembly: That within 30 days after the taking effect of this Act the Governor of the State shall appoint a State Board of Examiners of Structural Engineers, to be composed of five members, one of whom shall be a professor in the Civil Engineering Department of the University of Illinois, and the others shall be structural engineers of recognized standing, who have had not less than 10 years practical experience, then practicing as structural engineers in the State of Illinois, to hold, regulate, supervise and control examinations of applicants for license to practice structural engineering in this State. Two of the members shall be designated to hold office until Jan. 31, 1917, and the other three shall hold office until Jan. 31, 1919; and thereafter upon the expiration of the term of office of the persons so appointed, the Governor of the State shall appoint a successor to each person whose term of office shall expire to hold office for four years, and said person so appointed shall have the above specified qualifications. In case appointment of a successor is not made before the expiration of the term of any member, such member shall hold office until his successor is appointed and duly qualified. Any vacancy occurring in the membership of the Board shall be filled by the Governor of the State for the unexpired term of such membership.

Sec. 2. The members of the State Board of Examiners of Structural Engineers shall, before entering upon the discharge of their duties, make and file with the Secretary of State the constitutional oath of office. They shall, as soon as organized, and biennially thereafter in the month of February elect from their number a President and a Secretary who shall also be the Treasurer. The Treasurer, before entering upon his duties, shall file a bond with the Secretary of State, for such a sum as shall be required of him by the Secretary of State, and in such form and with such sureties as may be approved by the Governor of the State. The Board shall adopt rules and regulations not inconsistent with this Act to govern its proceedings; shall adopt a seal; and shall cause the prosecution of all persons violating any of the provisions of this Act, and may incur necessary expense in that behalf. The Secretary shall have the care and custody of the seal; and shall keep a record of all the proceedings of the Board which shall be open at all times to the public.

The Secretary of the Board shall receive a salary to be fixed by the Board, and which shall not exceed the sum of $1,500 per annum; he shall also receive his traveling and other expenses incurred in the performance of his official duties, and each of the other members of the Board shall receive the sum of $10 for each day actually engaged in the performance of his duties, and all legitimate and necessary expenses incurred in attending the meetings of the Board and in conducting examinations, which together with all other lawful expenses shall be paid from funds appropriated therefor, as provided by law.

Sec. 3. Three members of the Board shall constitute a quorum. Meetings of the Board shall be called by the Secretary upon the written request of the President or any two members, by giving at least seven days' written notice of such meetings to each member, counting from the day on which the notices are post-marked, telegraphed or personally delivered.

The Board shall adopt rules and regulations for the examination of applicants for license to practice structural engineering, in accordance with the provisions of this Act, and may amend, modify, and repeal such rules and regulations from time to time. The Board shall immediately upon the election of each officer thereof, and upon the adoption, repeal or modification of its rules of government or its rules and regulations of examinations of applicants for licenses, file with the Secretary of State and publish at least twice in at least one engineering journal of general circulation in the State of Illinois and in one daily newspaper published in the State of Illinois, the name and address of each officer, and a copy of such rules and regulations, or the amendments, repeal or modification thereof.

Sec. 4. Provisions shall be made by the Board hereby constituted for holding examinations at such place or places as shall be appointed by the Board, and at least two in each year, of applicants for license to practice structural engineering. Notice of the time and place of the holding of such examinations shall be published in the same manner as is hereinbefore provided for the publication of the rules and regulations pertaining to such examinations adopted by the Board, provided that the last day of such publication shall be at least 20 days prior to the date of holding such examinations. Each applicant shall pay to the Secretary of the Board, in advance, a fee of $20, and shall present his affidavit that he is of the age of 21 years, or above. Such examinations shall be held by the examiners as a body, a majority of whom shall constitute a quorum, or by a committee of two or more members selected and appointed by the Board. Examinations shall be conducted by written or printed interrogatories, in whole or in part.

Each applicant examined shall sustain a satisfactory examination in the design and construction of buildings and structures according to scientific principles and with special reference to strength and safety; the strength and properties of the various building materials; the principles of theoretical and applied mechanics; the ability of the applicant to applpy his knowledge to the ordinary requirements of structural engineering; and in such other matters and subjects as the Board of Examiners may require as suitable to fairly and thoroughly test the competency of the applicant to practice structural engineering in this State.

Every applicant for a license, except those who apply by virtue of the provisions of Sections 5 and 6 of this Act, shall present to the Board of Examiners satisfactory proof, by affidavit, or otherwise, as the Board may direct:

(a) That at the time of the taking effect of this Act, he was actually engaged in the practice of structural engineering in this State, and did not apply for a license under Section 5 of this Act, and in such case the applicant shall be entitled to an examination without regard to the number of years he has practiced. Or,

(b) That within 10 years next prior to his application, he has practiced structural engineering in some state or territory of the United States, or in some foreign country, for not less than six years, during at least two full years of which period he shall have been in responsible charge of work, as principal or assistant. Or,

(c) That within 10 years next prior to his application, he has pursued a course of study and training in the theory and practice of structural engineering covering at least the subjects above specifically enumerated, for the period of not less than six years, in the employ or under the supervision, direction and tuition of one or more practicing structural engineers, during at least two full years of which period, every such applicant shall show that he has been in charge of work in designing or construction in the employ or under the direction of such engineer or engineers. Such applicants who have graduated from a college or school of engineering considered by the Board to be in good standing and requiring a course of study of not less than four years, during at least 30 weeks in each year, shall be credited two years upon the 6-year period required above, the remaining four years to be pursued as hereinabove in this paragraph provided. The Board in its discretion may adopt rules providing for credit not exceeding two years on said 6-year period to applicants who have pursued a course of instruction in schools or colleges of engineering approved by the Board, but who have not graduated.

If the result of the examination of any applicant shall be satisfactory to a majority of the Board, under its rules, the Secretary, upon an order of the Board, and upon payment by said applicant of the further sum of $30, shall issue to said applicant a license to practice structural engineering in this State, in accordance with the provision of this Act, which license shall contain the full name, birthplace, and age of the licensee, and shall be signed by the President and Secretary and sealed with the seal of the Board.

All papers received by the Secretary in relation to applications for license, shall be kept on file in his office, and proper index and record thereof shall be kept by him.

Any fraudulent act or representation by any applicant in connection with his application for examination, or for a license without examination, under this Act, or during the conduct of his examination, shall be sufficient cause for the withholding of the license by the Board of Examiners or for its revocation after it has been issued.

Sec. 5. Any person who shall by affidavit or other proof as the Board may direct, show to the satisfaction of the State Board of Examiners of Structural Engineers that he was a resident of and engaged in the practice of structural engineering in this State, on the date of the taking effect of this Act, shall be entitled to a license without examination, provided such application shall be made within six months after the taking effect of this Act. Such license, when granted, shall set forth the fact that the person to whom the same was issued was practicing structural engineering in this State at the time of the taking effect of this Act, and is therefore entitled to the license to practice the profession of structural engineering without an examination by the Board of Examiners, and the Secretary of the Board shall upon the payment to him by the applicant of a fee of $50 issue to the person named in said affidavit a license to practice structural engineering in this State in accordance with the provisions of this Act.

Sec. 6. The State Board of Examiners may in its discretion, issue a license, without examination, upon payment of a fee of $50, to a structural engineer licensed under the laws of any other state or territory of the United States, or any foreign country, provided it appear to the Board that in the state or territory or country in which such license was issued, the requirements for a license to practice structural engineering were equal to those prescribed in this State, and that such state, territory or country accord a like privilege to structural engineers who hold licenses issued under the provisions of this Act.

Sec. 7. Every person holding a license to practice structural engineering in this State shall have it recorded in the office of the Secretary of State and the date of recording shall be endorsed thereon, and upon such recording said license shall be of force and effect throughout the State. The Secretary of State shall be entitled to receive a fee of $1 for the recording of each license filed for record. Until such license is recorded as herein provided, the holder thereof shall not exercise any of the rights or privileges conferred therein and thereby.

Sec. 8. Every licensed structural engineer shall have a seal, the impression of which must contain the name of the structural engineer, his place of business, and the words "Licensed Structural Engineer," "State of Illinois," with which he shall stamp all plans, drawings and specifications issued by him for use in this State.

Sec. 9. Persons licensed to practice structural engineering in this State under this Act shall be exempt from the provisions of "An Act to provide for the licensing of architects and regulating the practice of architecture as a profession," approved June 3, 1897, and in force July 1, 1897, and all amendments thereto.

Sec. 10. No corporation shall be licensed to practice structural engineering, but it shall be lawful for it to prepare drawings, plans and specifications for buildings and structures as defined in this Act, which are constructed, erected, built or their construction supervised by such corporation, provided that the chief executive officer or managing agent of such corporation in the State of Illinois shall be a structural engineer licensed under this Act.

Sec. 11. It shall be lawful for one or more licensed structural engineers to enter into copartnership with one or more architects licensed under the laws of this State, for the practice of their profession.

Sec. 12. Any person who shall be engaged in the designing or supervising of the construction, enlargement or alteration of any structures, other than buildings, as hereinafter defined, or any part thereof, for others, and to be constructed by persons other than himself shall be regarded as practicing structural engineering within the meaning of this Act, and shall be held to comply with the same. Structures within the meaning of this Act shall be construed to mean all structures other than buildings, having as essential features, foundations, columns, girders, trusses, arches and beams, with or without other parts, and in which safe design and construction requires that loads and stresses must be computed and the size and strength of parts must be determined by mathematical calculations based upon scientific principles and engineering data, and any person who shall be engaged as a principal, in the designing and supervision of the construction of structures or the structural parts of structures designed solely for the generation of electricity, or for the hoisting, cleaning, sizing or storing of coal, cement, sand, grain, gravel or similar materials, elevators, manufacturing plants, docks, bridges, blast furnaces, rolling mills, gas producers and reservoirs, smelters, dams, reservoirs, waterworks, sanitary works as applied to the purification of water or plants for waste and sewage disposal, or roundhouses for locomotives, railroad shops, pumping or power stations for drainage districts, or power houses, shall be considered as structural engineers within the meaning of this Act, and shall be entitled to the benefits of these provisions, even though such structures may come under the definition of "buildings" as defined in "An Act to provide for the licensing of architects and regulating the practice of architecture as a profession," approved June 3, 1897, in force July 1, 1897, and all amendments thereto; provided, however, that nothing contained in this Act shall be construed to limit or abridge the rights, privileges and duties of architects licensed to practice under the provisions of said Act, nor to modify, limit or repeal any of the provisions of said Act; and provided, further, that nothing contained in this Act shall prevent draftsmen, students, clerks of work, superintendents and other employees of those legally practicing as structural engineers under licenses as herein provided for, from acting under the instructions, control or supervision of their employers or shall prevent the employment of superintendents of construction paid by the owner from acting if under the control and direction of a licensed structural engineer who has prepared the drawings and specifications for the structure; and provided, further, that nothing contained in this Act shall be construed to prevent any person, mechanic or builder from making plans or specifications, or supervising the construction, enlargement or alteration of any structure or building which is to be constructed by himself or his employees, and for his own use.

Sec. 13. After six months from the taking effect of this Act, it shall be unlawful for any person to practice structural engineering without a license in this State, or to advertise, or to display a sign or card, or other device which indicates or represents that he is entitled to practice as a structural engineer in this State, and any person guilty of the violation of any of the provisions of this Act shall be punished by a fine of not less than $10 nor more than $200 for each and every offense.

Sec. 14. It shall be lawful and be the duty of the State Building Commissioner appointed and acting under any State Building Code which is now or which may hereafter be in force and effect in this State, or of any Building Commissioner of any city, town or village organized under any general or special law of this State, which has adopted a building code or other ordinance or laws relative to the construction, alteration, repair, maintenance and safety of buildings and structures, and providing for the issuing of building permits by a Building Commissioner or other officer designated for that purpose, to issue permits for the construction, enlargement or alteration of such buildings, as defined in Section 12 of this Act, or structures to any owner, or his agent, upon the filing with the State Building Commissioner or with the Building Commissioner of such city, town or village, of a true copy of the plans, drawings and specifications for the construction, enlargement or alteration of such buildings or structures, and a certificate signed by the structural engineer who executed them certifying under his seal that said plans, drawings and specifications are in accordance with the State Building Code, or the Building Code of such city, town, or village, as the case may be, provided, such structural engineer shall be licensed under this act, and provided, such owner or his agent has complied with all other requirements of law requisite to obtain such building permit, and provided, further, that such plans, drawing and specifications are in accordance with the State Building Code, or the Building Code of such city, town or village, as the case may be.

Sec. 15. Every licensed structural engineer in this State, who desires to continue the practice of his profession, shall annually, during the time he shall continue in such practice, pay to the Secretary of the Board during the month of July, a fee of $10, and the Secretary shall thereupon issue to such licensed structural engineer a certificate of renewal of his license for the term of one year. Failure by any licensed structural engineer in actual practice to cause his license to be renewed during the month of July in each and every year, shall constitute valid grounds for the revocation of his license. The failure to renew such license in apt time shall not deprive such structural engineer of the right of renewal thereafter; but the fee to be paid upon the renewal of a license after the month of July shall be $15.

It shall be the duty of the Secretary of the Board to file with the Secretary of State on the 15th days of February and August in each year certified lists of all licenses then in force, upon the filing of each of which said lists, the Secretary of State shall be entitled to receive a fee of $1.

Sec. 16. Licenses issued in accordance with the provisions of this Act shall remain in full force unless revoked for cause, as hereinafter provided. Any license so granted may be revoked by a four-fifths vote of the State Board of Examiners for gross incompetency; or recklessness in the construction of buildings or other structures; or for fraudulently affixing his seal to plans, drawings or specifications; or for any dishonest practice or practices on the part of the holder thereof; or for fraud in obtaining his license; or practicing without payment of the annual license renewal fee provided in Section 15 of this Act; but before any license shall be revoked such holder shall be entitled to at least twenty days' notice of the charge against him, and of the time and place of the meeting of the Board for the hearing and determining of such charge.

For the purpose of carrying out the provisions of this Act relating to the revocation of licenses, the Board, and each member thereof, shall have the power to administer oaths, and said Board shall have the power to secure by its subpoena both the attendance and the testimony of witnesses, and the production of books and papers, relevant to any investigation by the Board for the purpose of carrying out the provisions of this Act, relating to the revocation of licenses. Witnesses shall be entitled to the same fees and mileage as witnesses in a Court of Record, to be paid in like manner. The accused shall be entitled to the subpoena of the Board for his witnesses, and to be heard in person or by counsel in open public trial. Any Circuit Court of this State or any judge thereof, either in term time or vacation, upon application of such Board, may in its discretion by order duly entered by such court or judge thereof, require the attendance of witnesses, the production of books and papers, and giving of testimony before such Board, and upon refusal or neglect to so appear and testify and produce such books and papers as commanded by such order of the court or judge thereof, may compel, by attachment or otherwise, as provided by law, the attendance of such witnesses, the production of such books, and papers and the giving of testimony before such Board, in the same manner as production of evidence may be compelled before said court. Every person who, having taken an oath or made affirmation before said Board, shall willfully swear or affirm falsely, shall be guilty of perjury and upon conviction shall be punished accordingly. It shall be the duty of the Secretary of the Board to promptly give notice of all revocations of licenses to the Secretary of State who shall make an entry thereof in his records.

Sec. 17. The State Board of Examiners shall have power to entertain and grant for good cause shown, petitions to vacate its orders revoking licenses and reinstate such petitioner to practice in this State, and to adopt rules and regulations governing the requirements and hearing of such petitions, provided that at least one year shall intervene between the date of the entry of the order revoking a license and the filing of such petition in cases involving gross incompetency, recklessness, dishonest practices, or fraud. The Board in its discretion may require petitioners whose licenses have been revoked for gross incompetency or recklessness to submit to an examination by the Board touching their professional qualifications and competency to practice, which shall at least cover the subjects required of applicants for a license by examination. Such petitions shall briefly state the date and cause of revocation, the grounds upon which petitioner seeks reinstatement, and such other facts as the Board by its rules may prescribe, and shall be verified by the petitioner. The Board in the hearing of such petitions shall, as near as may be, follow the practice required by this Act in relation to citations to revoke licenses. Any person interested may appear and contest such petitions. A majority vote of the Board shall be sufficient to reinstate such petitioners to practice.

Every petitioner shall pay to the Secretary of the Board, in advance, upon the filing of his petition, a fee of $10.

It shall be the duty of the Secretary of the Board to promptly notify the Secretary of State of the reinstatement of any such applicant, and the Secretary of State shall note the same on his records accordingly.

Sec. 18. It shall be the duty of the Secretary of the Examining Board to file at the close of each fiscal year with the Auditor of Public Accounts of the State of Illinois, a full annual report of the proceedings of the Board, including a statement of all funds received and disbursed, and he shall also pay over to the State Treasurer of the State of Illinois, quarterly, all license fees and renewal and other fees collected by him during the preceding quarter and take his receipt therefor. Said report shall be attested by the affidavits of the President and Secretary.

## THINGS WE DO NOT KNOW ABOUT STRUCTURAL ENGINEERING.*

Omitting the assumptions relative to the loads, it is apparent that the assumptions which enter the design of a bridge which demand special attention on the part of the designer refer to the following: Secondary stresses; distribution of stress in a member; and distribution of stress in a connection.

### Secondary Stresses.

One of the fundamental assumptions in stress analysis is that connections are frictionless hinges. If a truss having frictionless hinges is deflected, the members meeting at a joint are free to rotate relative to each other and no bending stresses are produced in the members. If, however, the connections are rigid, when a truss is deflected the members are not free to rotate relative to each other and bending stresses, known as secondary stresses, are produced. These secondary stresses can be determined mathematically. While all are willing to admit that, theoretically, secondary stresses exist, many, apparently because of the elaborateness of the calculations necessary for their determination, look upon them as something invented by the mathematician for the further torture of the soul of the engineer. The strain-gage, however, has come to the support of the mathematician and secondary stresses are known to be a reality.

Secondary stresses equal to 50 per cent of the primary stresses are common. To just what extent such secondary stresses increase the danger of failure, however, is not clear. Upon first thought it would seem that introducing a secondary stress equal to 50 per cent of the primary stress would increase the danger of failure as much as if the primary stress were increased 50 per cent. This, however, is not the case. A secondary stress, being a bending stress, is not uniform over the section, and if the maximum values of the combined primary and secondary unit stresses exceeds the proportional limit of the material Hooke's law no longer applies, and there will be but little increase in the combined stress beyond the proportional limit. Just what value of combined primary and secondary stress can be used as a working stress has not been agreed upon by engineers.

Although secondary stresses can be computed, the calculations are so long that they are not at present made except in the case of the more important structures. For ordinary structures secondary stresses do not appear in the calculations and are not mentioned in the specifications. The view is held by many engineers that secondary stresses need not be considered since with an allowable unit stress of 16,000 lb. per square inch a secondary stress equal to 50 per cent of the primary stress produces a total stress considerably below the yield point of the material. If secondary stresses were equal in all members of a truss and in all types of trusses this position could be defended since the method would result in a structure for which all members would have the same factor of safety. But secondary stresses do not bear the same relation to the primary stresses in all members of a truss, and the secondary stresses are not the same in all types of trusses. The result is that designs are not properly balanced. Furthermore we are unable to judge intelligently of the relative merits of different types of trusses.

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*From a paper by W. M. Wilson, Assistant Professor of Structural Engineering, University of Illinois, presented on Oct. 9 before the Western Society of Engineers.

The calculation of secondary stresses is a long and tedious process, but like all long processes it shortens with repetition. In the early days of bridge design moment tables were unknown. Moreover to the student first introduced to the problem of primary stresses due to moving loads, the determination of the stresses in a six-panel truss due to a Cooper's loading is almost an overwhelming job even with a moment table, whereas to the experienced designer equipped with modern tables it is a small part of a forenoon's work. If we once recognize the necessity of determining secondary stresses, may we not hope for a similar development in the methods by which they are determined? The design of short and medium length spans has been standardized, and if the secondary stresses are computed in a few of each of the common types of trusses, may we not hope to establish empirical laws by means of which the secondary stresses in other trusses may be determined in a comparatively short time? Thus it would be possible to design all members with approximately the same factor of safety after secondary stresses have been included.

The resulting more perfectly balanced design would be a sufficient reason for making an extended systematic study of secondary stresses in standard trusses. There are, however, other results to be obtained from such a study which are even more important. A more intimate knowledge of secondary stresses would result in the abandonment of types of trusses having high secondary stresses and the substitution for them of trusses having low secondary stresses. An illustration of this is to be found in the attempts to use the K-type of truss of the Quebec bridge for shorter spans. Moreover, being confronted with high secondary stresses, the engineer would exercise his ingenuity to devise details which would reduce the secondary stresses. This is illustrated by the recent use of pin connections between the floor beams and trusses to reduce the secondary stresses in the vertical posts of trusses.

### Distribution of Stresses in a Member.

The area of the section required for a member subjected to a known stress is obtained by dividing the total stress by the allowable unit stress for the material. This is virtually equivalent to assuming that the stress is uniformly distributed over the area of a section of the member. Tests show that if an angle is riveted to a gusset plate by means of rivets in one leg only, the full strength of the angle can not be developed. Members of trusses are much larger than the single angles tested, and some portions of the section are a considerable distance from the central point in the connection. Engineers recognize the necessity of attaching the member to the gusset plate over as large a portion of the section as possible. In considering the value of the auxiliary parts of a connection, such as lug angles, it is well to bear in mind that where there are several paths for a stress the portions of the total stress which travel over the different paths depend upon the relative stiffness of the paths. To illustrate the truth of this statement consider again the case of a single angle riveted to a gusset plate. The connection of one leg to the gusset plate by means of a rivet holding the two pieces in immediate contact is very rigid. A lug angle attached to the gusset plate and to the outstanding leg of the main angle, comparatively speaking, is not rigid. The result is that a strain which ruptures the leg of the angle riveted directly to the gusset plate produces but little stress in the lug angle. This statement is supported by tests. Reasoning by analogy if the different parts of a connection are not equally rigid the stiffer parts may be overstressed, if not actually ruptured, before the more flexible parts of the connection receive an appreciable stress. It is true that as the stress in the most rigid part passes its proportional limit a part of its load is automatically transferred to other parts of the connection, but in the case of the angle connected to the gusset plate one part of the connection is so much more rigid than the other that the two parts act in succession instead of in unison. The same action is even more likely to occur in the connections for large truss members. Let me repeat, the portion of the stress which follows one path depends not at all upon the strength of the path but depends entirely upon its rigidity, and the stress in a member is not uniformly distributed over a section at the end unless the different parts of the connection are properly proportioned, one to another, relative to their rigidity.

It is the writer's opinion that for ordinary working loads the stress at the end of a member is not uniformly distributed over the section, and that the maximum unit stress is materially greater than the total stress divided by the area of the section. Furthermore, it is the opinion of the writer that ultimate failure of many members connected as they are in bridges, will occur at a stress materially below the ultimate unit strength of the material multiplied by the area of the section of the member. Since the advent of the strain gage the first statement can be either verified or disproved by means of field tests of bridges under normal working conditions without a prohibitive expense. The second statement can be checked by tests to destruction.

The important thing to be revealed by such tests is the efficiency of the different types of sections. If a member having one section can develop a stress of only 80 per cent of the product, area times unit strength of material, whereas if the member had a different type of section it could, because of the better type of connection possible, develop 90 per cent of the product, area times unit strength of material, then other things being equal the latter type of member should be used. At present we have but little, if any, reliable data relative to the efficiency of connections for different types of members. We have many opinions, but few facts.

### Distribution of Stresses in Connections.

The discussion of the distribution of stresses in a member is equally pertinent to the distribution of stresses in a connection. If the connection is made up of a number of parts each of which is to take a certain prescribed portion of the total stress, each part must have just sufficient rigidity to enable it to take its portion of the total stress. This condition it is practically impossible to obtain.

In a riveted connection the stress is not uniformly distributed among the rivets. The rivets are distributed over a considerable distance, and the intensity of the stress in the gusset plate at its outer edge is zero whereas the intensity of the stress in the member at the same point is a maximum. The intensity of the stress in the main member at its end is zero whereas the intensity of the stress in the gusset plate at the same point is a maximum. At some intermediate point the intensity of the stresses in the gusset plate and in the main member are equal. Designate this point as the working point. If the main member is in tension, the portion of the member between the working point and the edge of the gusset plate will elongate more under stress than the corresponding part of the gusset plate, and, therefore, the rivets at the edge of the gusset plate will be strained more than the rivets at the working point. Likewise the portion of the main member between its end and the working point will be stressed less than the corresponding portion of the gusset plate, and, therefore, the rivets at the end of the main member will be strained more than the rivets at the working point. That is, where we have assumed the stress to be uniformly distributed among the rivets we know that it is not so distributed. It follows, therefore, that the maximum stress per rivet exceeds the quotient, total stress divided by the number of rivets. A comparison of the strain in a riveted joint for ordinary working stresses with the difference in the strains in the gusset plate and the main member, shows that the maximum stress per rivet may be very much greater than the average stress per rivet.

Since a riveted joint, at usual working loads, resists a stress by virtue of the friction between the pieces connected, and since a riveted joint takes a permanent set at loads much below the usual working loads, overload in a rivet subjected to a reversal of stress may cause the rivet to work loose and must be considered as a serious matter. This fact together with the fact that stresses on rivets are not uniformly distributed as assumed, but that the maximum may be much greater than the average, indicates that the number of rivets in the connections should be increased, especially for members subjected to a reversal of stress.

The uneven distribution of the stresses can only be reduced by reducing the lap of the main member on the gusset plate. This suggests the desirability of arranging the plates so as to put the rivets in double shear, thus reducing the number required, or, as has been suggested, of using a comparatively small number of large turned bolts instead of a large number of rivets.

The thickness required for gusset plates is another question that has no satisfactory answer. Some designers claim that a truss can be assembled with only 25 per cent for details, other designers use 50 per cent. The American Bridge Co. state that their trusses run about 33 per cent details. As gusset plates comprise a large part of the details, the percentage of details depends largely upon the thickness of the plates. The thickness of the plates can not be computed except that the strength of the rivets in bearing should develop the strength of the rivets in shear. Usually the plates are thicker than is necessary to meet this requirement. The outstanding fact is that the weight of a truss can be materially altered by changing the thickness of the gusset plates, and we have no positive evidence determining the proper thickness. We have opinions of course, but the man who assembles trusses on 25 per cent details is positive that any one using more than 25 per cent is wasting material, whereas the man who uses 50 per cent details is positive that any less than that endangers the structure.

In general, in judging of the merits of a connection, it is well to bear in mind that the main member is the major part and the connection is the minor part, and that it is not good logic to jeopardize the major part to save a little on the minor part. Furthermore, if the life of a bridge is determined by the time it will wear as a machine, it will be the connections that will wear instead of the main members. For this reason also the connections should be stronger than the members.

The whole question of the strength of connections is a field ripe for experimental investigation.

### Advantages to Be Gained From a More Exact Knowledge of the Behavior of Structures.

The object in having a more exact knowledge of the behavior of structures is not either to use more material or to use less material, but rather to use the material so that it will do the most good. The structure must be safe, but it should also be economical. The advantages to be gained are economy and safety.

Greater economy in design can be obtained from an increase in knowledge in two ways. If the stress in a member is determined with a high degree of accuracy, what is usually known as a factor of safety is in reality a factor of safety, whereas if the stress is not known, what is termed a factor of safety is largely a factor of ignorance, and the member is made unnecessarily large because of the uncertainty in regard to the stress. If the stress in a member is determined with a high degree of accuracy those types of structures and types of details will be selected for which the secondary stresses are a minimum, and either the safety of the structure will be increased or the cost of the structure will be decreased.

The most important advantage of an increased knowledge relative to the behavior of a structure, is the increase in the safety of the design. Shakespeare says that fear springs from ignorance. To the engineer the unknown is the source of danger.

With very few exceptions, failures have been due, not to error in calculations, but to error in the assumptions upon which the calculations are based. It is the failure of the material to have the properties with which it is credited, or the failure of the structure to resist a stress in the manner assumed, that causes all failures. Design is not solely a mathematical process. Every equation used is based upon assumptions. These assumptions, the foundation upon which our structure of stress analysis is built, need contant inspection.

Structural engineering has made wonderful progress both in design and manufacture. But it is only by keeping before us the importance of the factors that are neglected that progress is to continue. To the man with an inclination for research work, whether engaged in practicing engineering or in university work, structural engineering is a wonderfully attractive field.

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## SOME COSTS ON EXCAVATION AND CONCRETE FOR MAYFAIR PUMPING STATION, CHICAGO, ILL.

The city of Chicago now has construction under way on a large pumping station at Mayfair to supply water to the northwest portion of the city and parts of the adjacent suburbs. This station is to be equipped with seven vertical triple expansion pumping engines of 25,000,000 gal. each, together with necessary boilers and accessories. The station and excavation for the same occupies a space 286 ft. by 164 ft.

The excavation for the pumping station was started Sept. 16, 1915, and has been carried on by city day labor. The estimated quantity of earth to be removed was 56,000 yd. in place. The excavation was handled by means of a steam shovel loading into wagons that are hauled by teams belonging to a private contractor. The progress of the excavation to December 31, 1915, according to the recently issued report of the Department of Public Works, was as follows:

| | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|
| Yards excavated, in place | 1,600 | 8,370 | 8,900 | 10,850 | 29,720 |
| Yards excavated, loose | 2,090 | 13,200 | 13,710 | 16,714 | 45,714 |
| Number of working days of 9 hours each | 7 | 25 | 27 | 30 | 90 |
| Yards per day | 298 | 628 | 508 | 555 | 508 |
| Cost of labor and shovel per yard for loading | 36.1 | 15.2 | 20.8 | 30.6 | 23.8 |
| Cost per yard for hauling (cents) | .0 | 38.5 | 38.5 | 39.5 | 36.9 |
| | 36.1 | 53.7 | 59.3 | 70.1 | 60.7 |

The gradual increase in the unit cost is due to the increase in quantity of hand digging and bracing for the wall trenches.

The construction equipment consisted of one Marion-Osgood ¾-yd. steam shovel, one stiff leg steel derrick, one 90 H.P. electrically operated double drum hoist, two 50 H.P. electrically operated single drum hoists, one concrete mixer of 28 cu. ft. capacity and one locomotive crane.

The placing of concrete for coal receiving room footings was started Nov. 18 and to Dec. 31, 1915, 945 cu. yd. of concrete was placed.

The following is an analysis of labor costs:

| | | Forms | | Wrecking forms. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cubic yards. | Per yard. | Per sq. ft. | Per yard. | Per sq. ft. | Mix and placing. | Placing rods. | Finish. | Total cost of labor per cu. yd. |
| Coal room— | | | | | | | | | |
| Footings | 139 | $0.28 | ..... | ..... | ..... | $1.77 | $0.63 | ..... | $2.68 |
| Walls | 282 | .84 | $0.02 | $1.94 | $0.05 | 1.94 | .21 | $0.58 | 5.52 |
| Girders | 158 | 1.90 | .30 | .32 | ..... | 2.21 | .33 | ..... | 4.81 |
| Boiler room— | | | | | | | | | |
| Wall-footings | 185 | ..... | ..... | ..... | ..... | 1.21 | .29 | ..... | 1.50 |
| Wall | 181 | 4.40 | 1.41 | .52 | .02 | 1.75 | .28 | .38 | 7.33 |
| Average cost per cubic yard for 945 cu. yd. | ... | 1.43 | .78 | .01 | .04 | 1.72 | .33 | ..... | 4.47 |

The construction work at the Mayfair Pumping Station was in local charge of F. C. Martini, Assistant Engineer.

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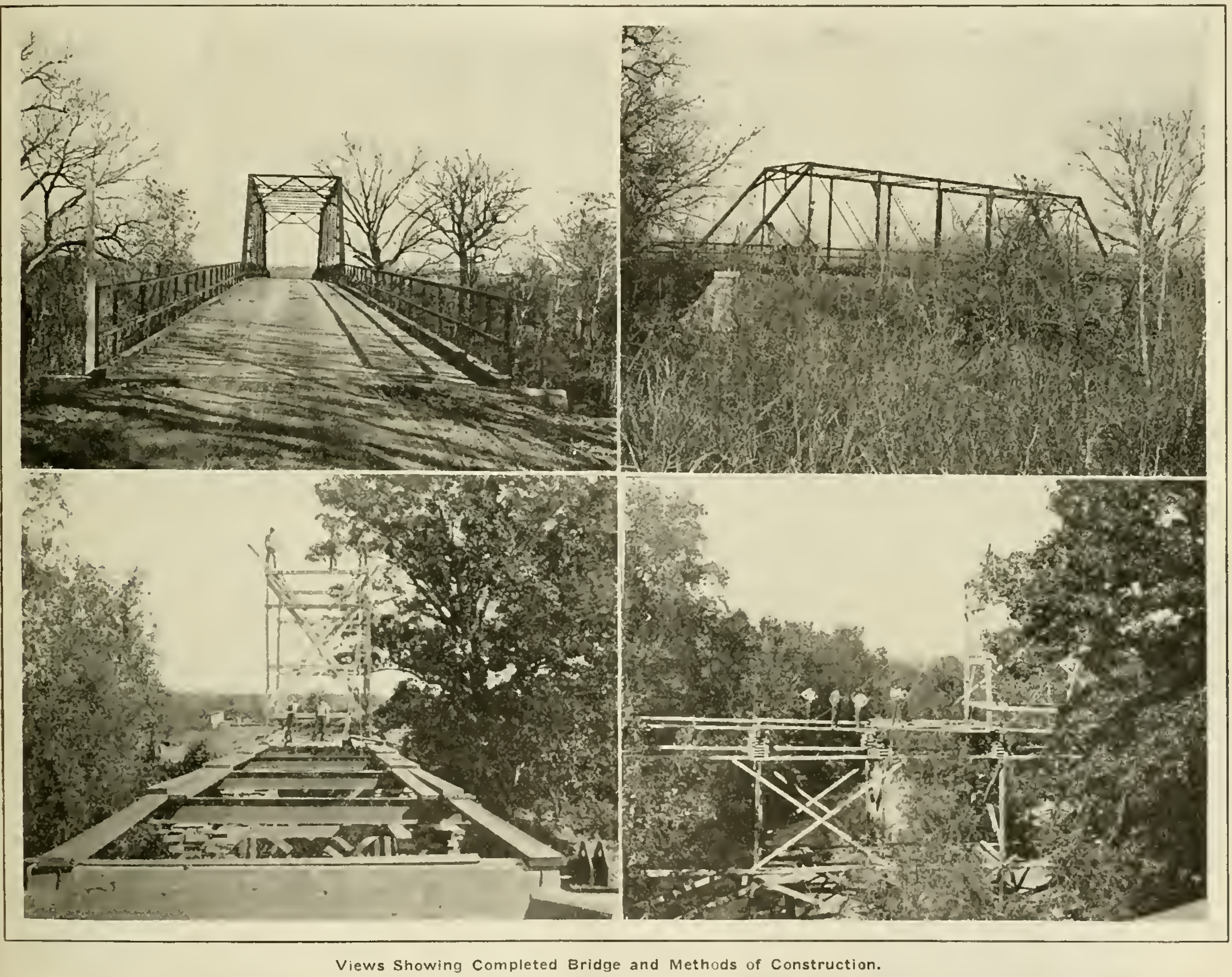
Plans have been submitted to officials of New York state for two power developments in the Upper Hudson Valley, calling for expenditure of $7,000,000.

# THE COST AND DETAILS OF CONSTRUCTION OF A STEEL HIGHWAY BRIDGE.

Contributed by William C. Davidson, Former Assistant County Engineer.

The structural steel highway bridge discussed in this article was recently built in McLennan County, Texas. It is one of about 500 bridges and culverts covering a territory which has 175 miles of improved highway. The site of the bridge is situated about 10 miles from Waco, the central location of the road improvement district. It spans Aquilla Creek, one of the larger tributary streams of the Brazos River. The structure has a total length of 273 ft., consisting of 120 ft. of main span and 153 ft. of timber trestle approaches.



Views Showing Completed Bridge and Methods of Construction.

Owing to the fact that this class of construction was not covered in the contractor's bid, it became necessary to handle the work under direct supervision of the county engineer. An experienced steel bridge foreman was employed to superintend the construction work, which was in direct charge of the writer as assistant engineer. Foundation excavation was commenced about July 1, 1915, and two months later the road and bridge were opened to traffic. To obtain a more direct alignment the site of the new bridge was moved several feet upstream from the site of the old structure.

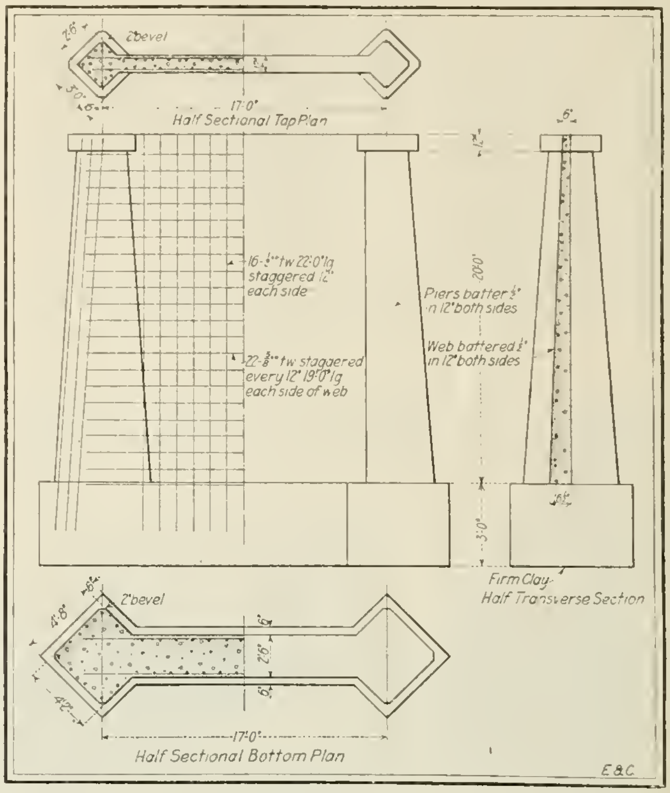
Labor for handling the work was obtained locally with the exception of a form-builder who was obtained from Waco. Common labor cost at the rate of $1.50 to $1.75 per day of eight hours each. The form builder was paid at the rate of $3 per day. Practically all the hauling was done under contract. Miscellaneous teaming was paid for at the rate of $0.40 per hour. The foreman was employed at $4 per day straight time, no overtime being allowed for more than an eight-hour day. Laborers were paid overtime for all work exceeding eight hours per day. It was necessary to haul a part of the material, such as form lumber, tools, equipment for camp outfit and other miscellaneous supplies, from Waco. This teaming was done by one of the county maintenance outfits, at a cost of $3 per day.

The nearest railroad spur was situated a distance of five miles from the site of the bridge. Cement, structural steel, bridge lumber, piling and wood preserver for treating certain portions of the wood work, were shipped to this point. The hauling of this material to the site was contracted to a local teamster at the following prices: Cement, 6⅔ ct. per sack; bridge lumber, 25 ct. per 100 ft. B. M.; structural steel, $1 per ton. The piling and wood preserver were hauled to the site at a cost of $0.40 per hour for man and team. Gravel for the pile footings and concrete piers was also hauled under contract. It was obtained from local pits situated two and five miles from the site, respectively. From the pit, located two miles distant, 130 cu. yd. were obtained at a cost of $0.50 per yard for the hauling and $0.10 per yard for the gravel. Added to the above cost was that of stripping the pit which amounted to $0.11 per yard, making a total cost per yard at the site of $0.71. Owing to the fact that the above pit would not supply sufficient gravel to construct the piers and footings, it became necessary to haul 39½ cu. yd. from another local pit situated five miles from the site. This gravel was contracted at $1.15 per cubic yard for loading and hauling and $0.10 per cubic yard for the gravel, making a total cost at the site of $1.25 per cubic yard. No stripping was necessary at this pit. Tickets were issued to the teamsters by the foreman for each load of gravel as it was received at the site, and payment was made upon the basis of these tickets. The invoices of the material companies were taken as the basis of payment for the haul of cement, steel and lumber.

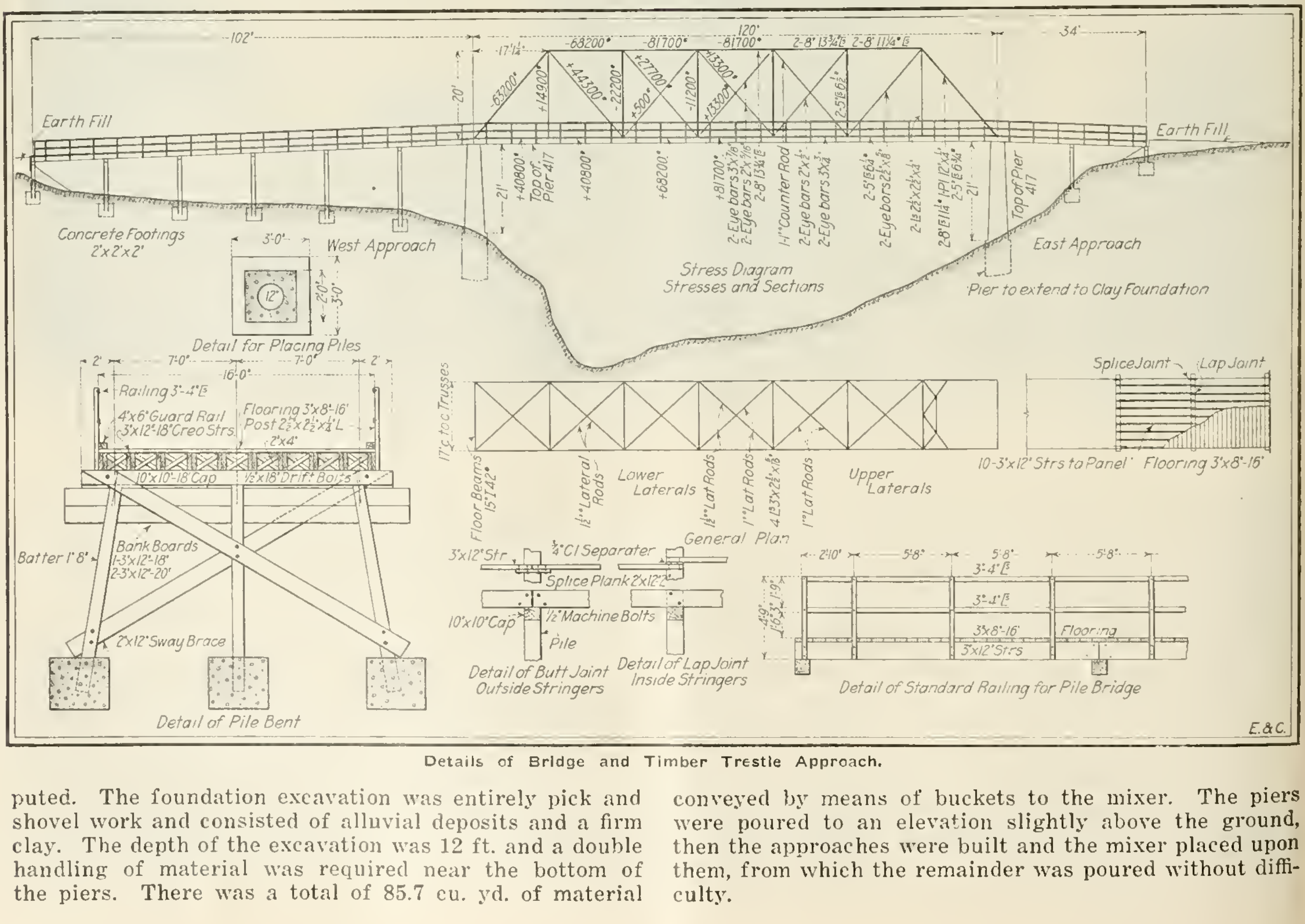
The following is an itemized statement of the cost of the bridge, including all material and labor:

| | |
|---|---|
| Material: | |
| Structural steel, f. o. b. cars at factory, 42,770 lb. @ $3.11 per 100 lb. | $1,325.87 |
| Freight on steel, 42,770 lb. @ 55c per 100 lb. | 235.24 |
| Bridge lumber, 25,335 ft. B. M. | 426.56 |
| Cement, 425 sacks @ 32c per sack net | 178.50 |
| Reinforcing steel, 4,455 lb. @ $2.75 per 100 lb. | 122.51 |
| Form lumber, 3,900 ft. B. M. | 104.39 |
| Piling, 454 lin. ft. @ 7½c per foot | 34.05 |
| Nails, 2 kegs 60d and 1 keg 6d | 7.85 |
| 2 rolls, No. 9 wire for forms | 4.90 |
| Gravel, 169½ cu. yd. @ 10c | 16.95 |
| Paint, 14 gal. @ $1.95 | 27.30 |
| Linseed oil, 4 gal. @ 85c | 3.40 |
| Machine bolts | 19.64 |
| Misc. tools and hardware | 29 98 |
| Paint brushes | 1.15 |
| Wood preserver | 5.00 |
| Total | $2,643.29 |
| Labor: | |
| Clearing of bridge site | $ 8.90 |
| Foundation excavation | 57.35 |
| Mixing and placing concrete | 78.40 |
| Building of forms | 165.05 |
| Removal of forms | 16.75 |
| Hauling form lumber | 12.00 |
| Hauling cement, 425 sacks @ 6⅔c | 28.33 |
| Hauling gravel, 169½ cu. yd. (130 cu. yd. @ 50c, 39½ cu. yd. @ $1.15) | 110.43 |
| Hauling reinforcing steel | 8.00 |
| Extra cutting of steel | .75 |
| Hauling bridge lumber | 65.42 |
| Erection of steel, including decking of main span and approaches | 207.20 |
| Construction and removal of false work | 51.50 |
| Building approaches (not decking) | 42.55 |
| Painting steel span (one coat) | 14.90 |
| Rent on storage house | 3.00 |
| Miscellaneous hauling: | |
| Moving concrete mixer from R. R. to site | 2.00 |
| Stripping gravel pits | 14.80 |
| Hauling cement from storage house to site | 3.60 |
| Hauling piling from R. R. to site | 8.00 |
| Unloading piling at R. R | 4.80 |
| Unloading bridge lumber at R. R. | 3.75 |
| Moving lumber at bridge | .40 |
| Foreman's time (60 days @ $4.00 per day) | 240.00 |
| Structural steel workman (connecting span) | 25.00 |
| Total | $1,172.68 |
| Cost of material | 2,643.29 |
| Grand total cost, material and labor | $3,815.97 |

**Unit Costs.**—On the basis of the foregoing cost data, unit costs on the several items of material have been computed. The foundation excavation was entirely pick and shovel work and consisted of alluvial deposits and a firm clay. The depth of the excavation was 12 ft. and a double handling of material was required near the bottom of the piers. There was a total of 85.7 cu. yd. of material taken from both piers, at a total cost of $57.35 or a unit cost of $0.67. Mixing and placing of concrete cost $78.30. The total cubic yardage of concrete in the piers and pile footings amounted to 125.7, from which is deduced a cost of $0.62 per cubic yard. Water used in mixing the concrete was obtained from the creek at the site by means of a hand pump. It was pumped into barrels to an elevation of about 20 ft. above the creek, from which it was conveyed by means of buckets to the mixer. The piers were poured to an elevation slightly above the ground, then the approaches were built and the mixer placed upon them, from which the remainder was poured without difficulty.


2"bevel
17'-0"
Half Sectional Top Plan
16-⅝" tw 22'-0" lg staggered 12" each side
22-⅝" tw staggered every 12" 19'-0" lg each side of web
Piers batter ⅛" in 12" both sides
Web battered ⅛" in 12" both sides
20'0"
3'-0"
Firm Clay
Half Transverse Section
2"bevel
17'-0"
Half Sectional Bottom Plan
E.&C.

Sections of Pier.



Details of Bridge and Timber Trestle Approach.

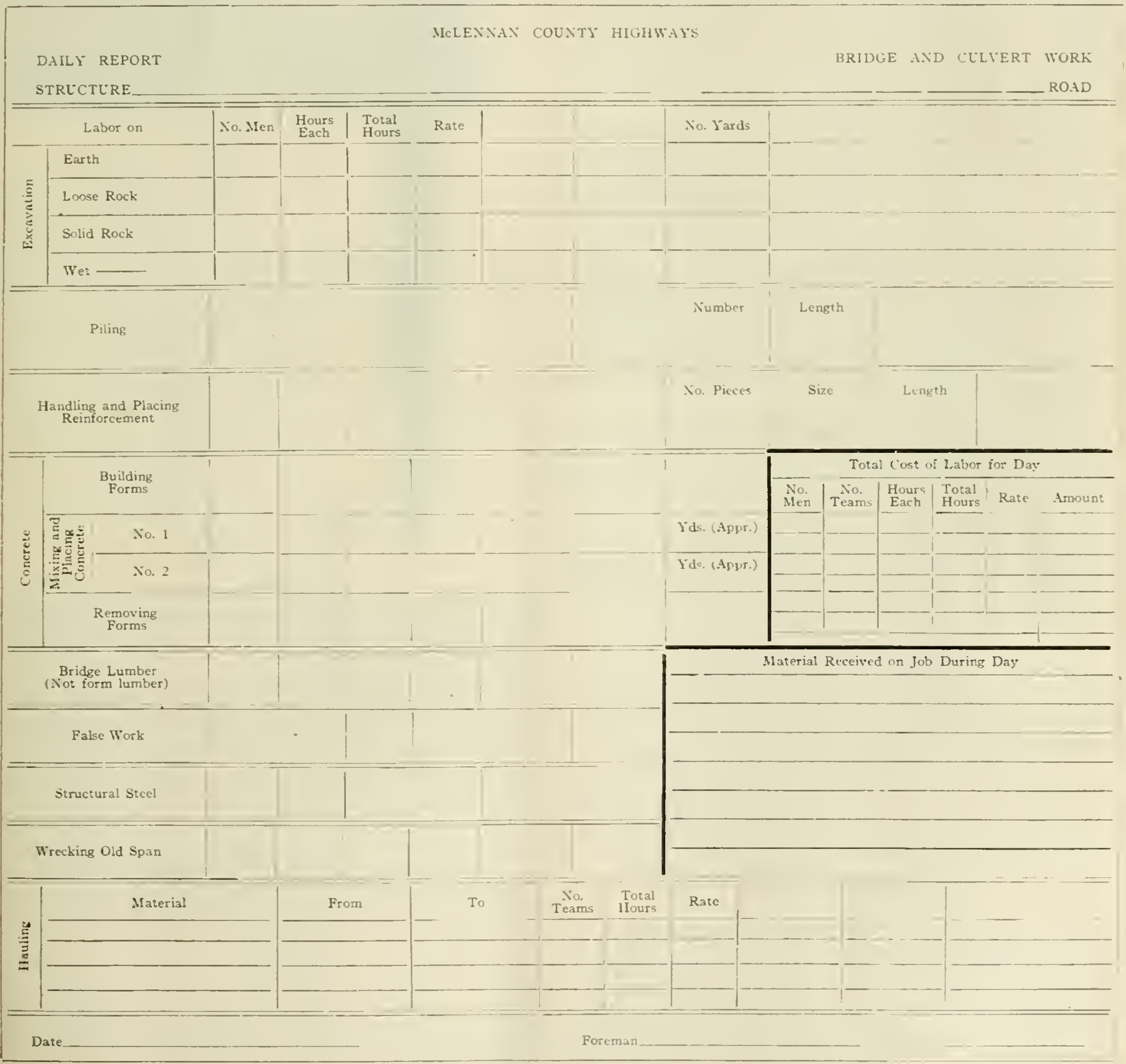
The piers being of rather unusual design, involved expensive form work from the standpoint of labor, the total cost being $165.05, or a unit cost per yard of concrete, of $1.33. The lumber, wire, nails, removal of forms and the hauling of form lumber amounted to $140.79, with a resultant unit cost for material of $1.12 per cubic yard. Therefore the total unit cost for forms was $2.45 per cubic yard, which is somewhat higher than is to be expected for form work on piers.

The total cost of the cement at the site, including first cost, hauling and storage, was $215.43, from which it is estimated that the cost for cement per cubic yard of concrete amounts to $1.70. The concrete gravel cost at the site $142.18, including first cost, hauling and stripping of pits. This results in a unit cost of $1.13 per cubic yard. The cost of water for the concrete was included in the item "mixing and placing" and the cost of placing reinforcing steel was not separated from that of building forms. From the foregoing a summary of cost per cubic yard of concrete is as follows:

| | |
|---|---|
| Cement | $1.70 |
| Gravel | 1.13 |
| Forms | 2.45 |
| Mixing and placing | .62 |
| Supplies for mixer | .02 |
| Foreman | .38 |
| Total | $6.30 |

The bridge was erected at a total cost for labor on superstructure and false work of $258.50, which cost included the erection of steel and the decking of main span and approaches. A cost of $0.95 per linear foot of bridge is deduced from the foregoing. It required material amounting to $31.85 to paint the steel work, with a corresponding cost per ton of steel of $1.49. Labor required amounted to $14.90 or a cost per ton of steel of $0.70. The total cost, therefore, per ton of steel for labor and material was $2.19.

**Construction Details.**—The structure under discussion had a total length of 273 ft. of which 120 ft. was main span and 153 ft. was timber trestle approach, consisting of three 17-ft. panels on one end and six 17-ft. panels on the other end. This bridge replaced an existing steel bridge having a main span of 117 ft. and about 200 ft. of approach. The location of the old bridge was such that it made a very undesirable crossing, owing to its general alignment and also an abrupt curve in one of the approaches. By shifting the center line of the new bridge about 150 ft. upstream, not only was an excellent alignment obtained, but a better crossing was found with respect to the channel itself. The old bridge had a width or roadway of 12 ft., which was entirely inadequate owing to the amount of traffic over the road and the length of the bridge. Teams starting upon the bridge at one end could scarcely see teams entering from the other end.



McLENNAN COUNTY HIGHWAYS

DAILY REPORT

BRIDGE AND CULVERT WORK

STRUCTURE________________ ________________ ROAD

| Labor on | | No. Men | Hours Each | Total Hours | Rate | | No. Yards |
|---|---|---|---|---|---|---|---|
| Excavation | Earth | | | | | | |
| | Loose Rock | | | | | | |
| | Solid Rock | | | | | | |
| | Wet —— | | | | | | |

Piling — Number — Length

Handling and Placing Reinforcement — No. Pieces — Size — Length

| | | | |
|---|---|---|---|
| Concrete | Building Forms | | |
| | Mixing and Placing Concrete No. 1 | | Yds. (Appr.) |
| | Mixing and Placing Concrete No. 2 | | Yds. (Appr.) |
| | Removing Forms | | |

Total Cost of Labor for Day

| No. Men | No. Teams | Hours Each | Total Hours | Rate | Amount |
|---|---|---|---|---|---|
| | | | | | |

Bridge Lumber (Not form lumber)

False Work

Structural Steel

Wrecking Old Span

Material Received on Job During Day

| Hauling | Material | From | To | No. Teams | Total Hours | Rate | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

Date________________ Foreman________________

Daily Report Form Used for the Day Labor Work.

The new structure had a width of roadway of 16 ft., which was sufficient width to accommodate two teams passing upon the bridge at the same time.

The concrete used in the construction of the piers was mixed in the proportion of one part of cement to six parts of pit run gravel. A form finish was given the outer surface of the piers. Vertical and horizontal reinforcing rods were used as shown on the pier detail. The steel was designed for what was designated in the standard specifications as a "Class B Loading." This consisted of a load of 80 lb. per square foot of total floor surface, being the equivalent of a 10-ton traction engine having axles 8 ft. on centers and a 6-ft. gage, two-thirds of the load to be carried on the rear axles and distributed over 12 ft. in width.

All panels of the bridge approaches were 17 ft. long, according to the general standard adopted for all trestle work throughout the county. The hand-railing for the approaches was also standardized. It consisted of steel channels for the railing and steel angles for the posts. The spacing of the posts as noted on the detail was uniform for all bridges of this type.

Wood preserver was used on the bottoms of caps where they rested on the piling and also on the tops where they came in contact with the floor joist. It was also put on top of all floor joists to prevent the rotting of same due to contact with the floor. The guard rails were treated with the preserver, where they came in contact with the wooden shims. The entire steel work was given one coat of black graphite paint after the bridge had been erected. This was in addition to the shop coat which was specified in the general specifications.

There were no unusual details involved in the design of the steel portion of the bridge nor the approaches, except the later represented a standard employed throughout the entire county. So far as the writer has been able to ascertain the pier design is unique and original. The idea belongs to Rollen J. Windrow, present county engineer and road superintendent of McLennan County, Texas. Details of the design of these piers were worked out under the direction of Mr. Windrow, and this is the design used for all piers for steel bridges throughout the county. Already several bridges have been built according to this design. They are pleasing in appearance and economical in material.

**Force Reports.**—In order to obtain accurate cost data of the work daily reports were kept by the foreman. The form of report used was standard for bridge and culvert work. It shows the distribution of labor throughout the day; the number of men employed; the number of hours each have worked; the total number of hours; and the rate per hour. The foreman was required to note on the report the approximate quantities of material handled during the day, such as concrete, excavation, piling, reinforcing, etc. He was also required to show the material delivered on the job during the day; the place from which it was hauled; the number of teams hauling; the total number of hours worked; and the rate per hour. There was provided on the report a space for a summary of the labor cost for the day. The foreman was required to make this summary, which was checked in the office when the cost was being compiled.

These reports were sent to the county engineer's office at the end of every two weeks, at which time the pay roll of the laborers was also sent to the office. The cost data was compiled as the work progressed, and hence a close check was kept on all items during the construction of the bridge.

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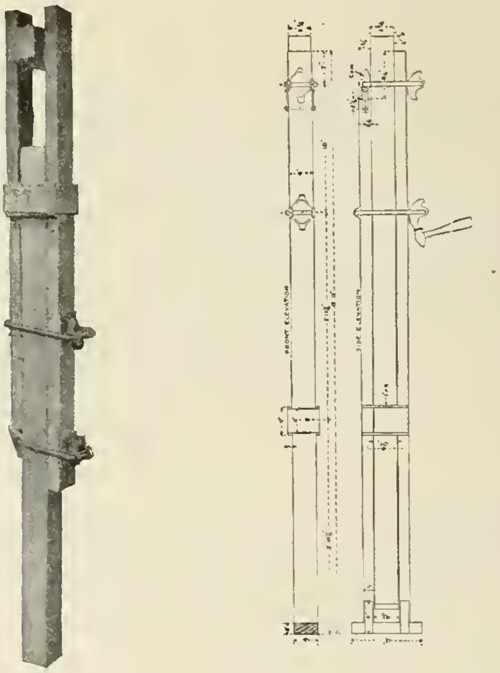
**To Assist Concrete Construction.**—The Extension Division of the Portland Cement Association, 111 W. Washington St., Chicago, Ill., is planning a nation-wide campaign for the purpose of assisting rural contractors specializing in concrete work or others desiring to undertake such work. Further particulars of this co-operative plan can be obtained by addressing the Director of the Extension Division.

## AN ADJUSTABLE SHORE FOR CONCRETE FORM-WORK.

An adjustable shore developed recently by Mr. Hodges, one of the superintendents of the Ferro Concrete Construction Co. of Cincinnati, O., has enabled the company to make very material decreases in its concrete form costs. These shores are used to hold up beam forms and floor forms, or in any other way that shores are ordinarily used on a concrete building job.

The construction of this new adjustable shore is simple. Three pieces of lumber are required. Experience and tests have proven that the following dimensions are the most satisfactory and if the shore is made from these dimensions it is even stronger than a rough 4 by 4 in. shore of the same length. The lumber should preferably be No. 1 common long leaf yellow pine, two 2 by 4s planed to 1¾-in. and one 4 by 4 in. planed to 3¾-in. by 3¾-in. All three should be about 8 ft. long. In addition to this lumber, which is assembled in accordance with the illustration shown, two special clamps are necessary. These operate by a small blow of the hammer, and fasten the three timbers into a rigid non-collapsible member which can be nailed to or braced at any point desired. The shore is instantly adjustable from 8 to 14½ ft.

The shore is sometimes made with a slotted head, and this type has certain advantages over the one shown in that it can be set up without any nailing or cleating whatever, and cannot fall down when struck or jarred. Neither type will collapse under load as can be readily seen by studying the action of the cams.



Adjustable Shore for Concrete Form Work.

In operation the shores are brought from the storage pile and deposited wherever needed on the job. The clamps are loosened and the 4 by 4-in. timbers drawn out to the desired length, this being determined by a measuring pole in the usual manner. The clamps are then tightened, the shores are raised and the stringers placed in position. Intermediate shores can be put into place without careful measuring and after the decking is on, can be leveled up by means of an engineer's level and shore jack in a fraction of the time which is usually required with wedges. With the Hodges shore wedges are unnecessary.

According to the experience of The Ferro Concrete Construction Co. in using these new shores, it seems that from 10 to 12 ct. can be saved on each shore every time it is used. Not only is there a saving in waste lumber but on account of freight rates, the actual cost of the lumber used in these shores is less than the cost of rough 4 by 4 stock for common shores.

## A TEMPORARY WOODEN BASCULE BRIDGE.

Contributed by W. F. Schaphorst, Woolworth Building, New York City.

In order not to obstruct the channel of the Missouri River during the construction of the new Burlington Bridge, a light wooden bascule bridge was used to handle material on. The trunnion for the north half of the span was supported by a double bent of 12 cypress piles, capped and braced. The towers were 12x12 timbers, fitted with ordinary timber derrick mast shoes, and were braced with 3x10s and 6x8s.

The leaves of the bridge consisted of 47-ft. timbers, carrying ties and rails for the construction railway, and braced laterally with 3x10s bolted to the under side of the 12x12s. The supporting cables comprised two strands of 5/8-in. steel wire.

Temporary Bascule Bridge.

The bridge was designed to carry a live load of 5,000 lb. at the center of the span. This was assumed to be the weight of one yard of concrete, with bucket and car. The concrete was transported by two cars, running on parallel tracks. A ½-in. cable hauled the cars by means of a two-drum hoisting engine. The haulage was from the mixing plant to the derrick on a pier of the new bridge.

When the ice broke up in the river the north half of the bascule bridge was swept away. The caisson for the pier at this location was not damaged, and the remainder of the concrete could be placed from a mixing plant located on the south bank of the river.

## COST OF COATING COAL BUNKERS WITH A CEMENT GUN.

The steel coal bunkers in connection with the boilers of the Roseland water works pumping station of Chicago, Ill., after about 4 years became badly pitted on the inner surface from the effects of the coal. In some places the steel was eaten through entirely. The bunkers had been painted every year, but this did not seem to furnish the required protection. Last year to protect this steel and avoid the expense of painting the bunkers were given a lining of concrete. The lining consists of from 2½ in. to 3½ in. of Portland cement plaster, reinforced with wire mesh. On the vertical side the reinforcing was attached by 3/8 in. rods run through holes drilled in the stiffener angles. The mortar was applied with a cement gun, and was coated with an application of a hardening paint.

The cost of covering the 3,424 sq. ft. of surface was as follows, according to the recently issued report of the Department of Public Works of Chicago:

| | Total. | Per sq. yd. |
|---|---|---|
| Scaffolding | $ 138 | $0.04 |
| Reinforcing | 210 | .06 |
| Plaster material | 204 | .06 |
| Placing | 608 | .18 |
| Hardening paint | 74 | .02 |
| Cleaning and miscellaneous | 68 | .02 |
| Engineering and superintendence | 52 | .02 |
| Operation | 203 | .054 |
| Totals | $1,557 | $0.454 |

## THE DESIGN OF STEEL STACKS.

Stack design in many cases has been carried out by a cut and try method which might or might not involve many trials before a solution was reached. In the Journal of Engineering of The University of Colorado, Mr. W. A. Hitchcock, Instructor in Engineering Mathematics, presents methods for obviating this difficulty and leading to direct results. In his article, which is reprinted below, practically in full, Mr. Hitchcock gives some new formulae and new diagrams:

The design of the steel stack will be considered under six subdivisions, viz.: (1) Working stresses; (2) Minimum thickness of plate in the shell; (3) Minimum size of foundation; (4) Minimum size of anchor bolts; (5) Riveting; (6) Base plate.

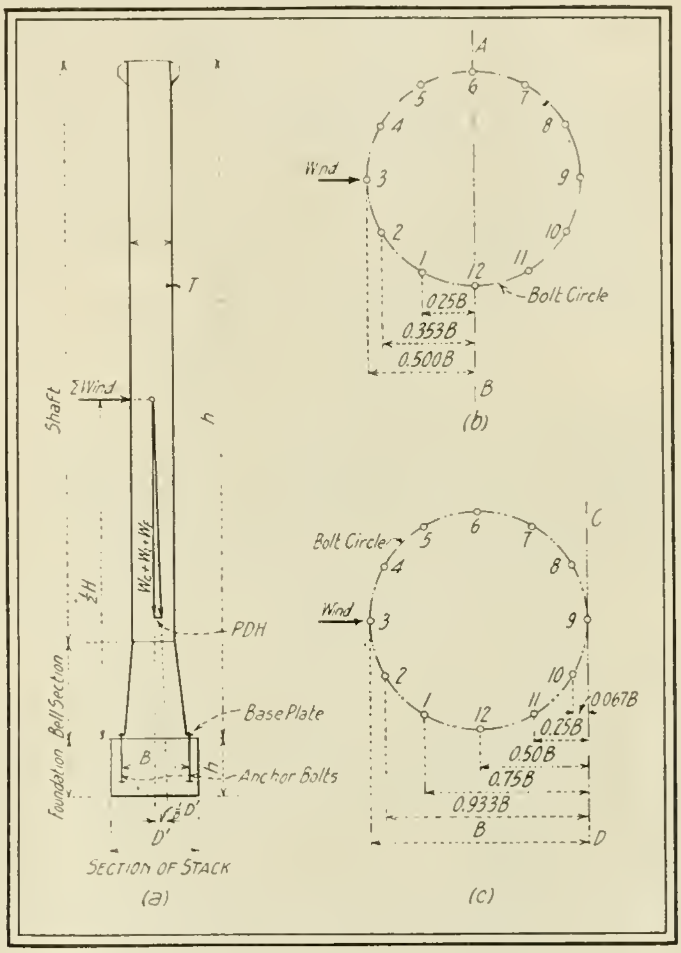


Fig. 1.

### Nomenclature.

H = height of stack in feet above any section;
d = outside diameter of the stack in inches;
d' = inside diameter of the stack in inches;
D = outside diameter of the stack in feet;
s' = unit stress in plate due to weight of stack above section;
s = unit stress in plate due to wind pressure;
S = total unit stress in plate;
E = efficiency of riveted joint;
T = thickness of plate in inches.
P = pressure of wind on projected diameter, lb. per sq. ft.;
D' = diameter of the foundation in feet, assuming a circular section;
h = height of foundation in feet;
We = weight of steel stack;
Wl = weight of stack lining;
Wf = weight of foundation;
b = diameter of each anchor bolt in inches;
B = diameter of the anchor bolt circle in feet;
t = allowable tension in a bolt at unit distance from the axis;
x = distance from axis to any bolt in feet.

### LOADS AND WORKING STRESSES.

The following working stresses are recommended:

| | |
|---|---|
| Plates, tension and compression | 16,000 lb. per sq. in. |
| Shop Rivets, shear | 12,000 lb. per sq. in. |
| bearing pressure | 21,000 lb. per sq. in. |
| Field Rivets, shear | 9,000 lb. per sq. in. |
| bearing pressure | 18,000 lb. per sq. in. |
| Anchor Bolts, tension | 15,000 lb. per sq. in. |

Wind Pressure: The wind pressure is assumed to be 20 lb. per sq. ft. on the projected diameter. (Prussian engineers use 17 lb.)

Weight of Concrete: The weight of concrete is taken as 150 lb. per cu. ft.

Efficiency: The average value for efficiency for double riveted joints is taken as 0.70; the average value for single riveted joints as 0.50.

### Minimum Thickness of Plate in the Shell.

For a stack as shown in Fig. 1 (a), the overturning moment due to wind pressure is

$$M = P \times D \times H \times 12 \times \tfrac{1}{2} H = \tfrac{1}{2} \cdot 12PDH^2 \text{ in. lb.}$$

or,

$$M = \tfrac{1}{2}PdH^2 \text{ in. lb.} \qquad (1)$$

The resisting moment at any section is given by

$$M = \frac{\pi(d^4 - d'^4)s}{32d}\text{; but } d' = (d - 2T)\text{, therefore}$$

$d'^4 = (d-2T)^4$, giving, if we neglect powers of T higher than the first which may be done as T is very small as compared with d, the resisting moment,

$$M = \frac{\pi \times 8 \times d^3Ts}{32d} = 0.7854\ d^2Ts \qquad (2)$$

Solving Equations (1) and (2),

$$s = \frac{PdH^2}{2 \times 0.7854\ d^2T} = \frac{0.053\ PH^2}{DT} \qquad (3)$$

or the stress per lineal inch along the circumference is

$$S' = \frac{0.053\ PH^2}{D} \qquad (4)$$

If E be taken as the efficiency of a riveted joint, equation (2) becomes,

$$M = 0.7854\ d^2TsE \qquad (5)$$

Solving Equations (1) and (5) for T, we have

$$T = \frac{PdH^2}{2 \times 0.7854\ d^2sE} = \frac{0.053\ PH^2}{DfE} \qquad (6)$$

which gives the thickness of plate necessary at any section to resist the moment due to wind pressure, for any fiber stress, f, and any efficiency.

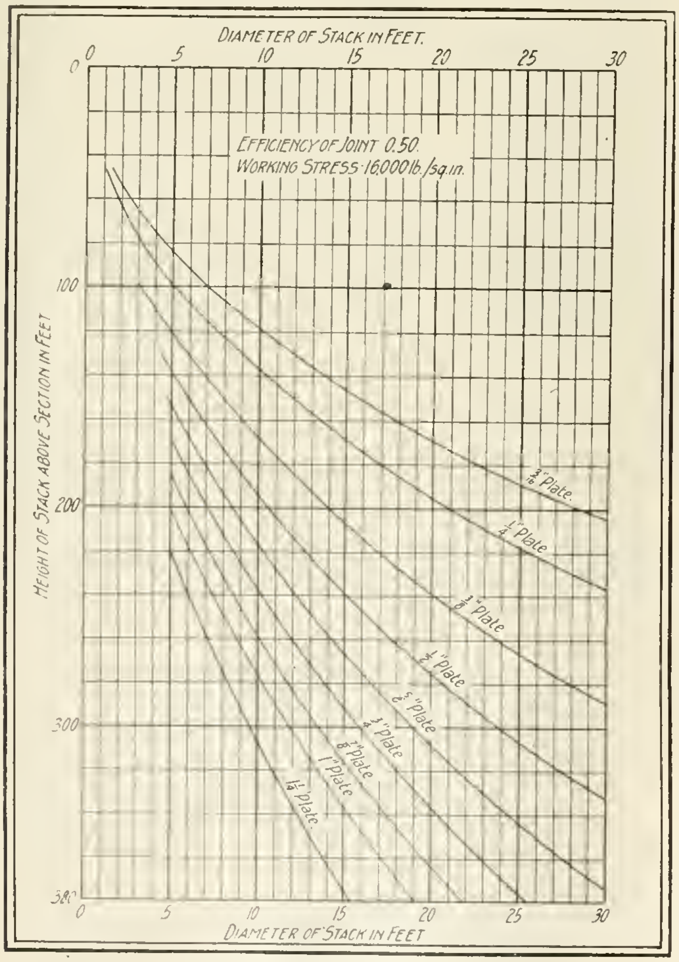


Fig. 2—Thickness of Plates.

The unit stress at any section due to the weight of the stack above the section is,

$$s' = \frac{W}{24\pi DT} = \frac{490\pi DHT}{144\pi DT} = 3.4\ H \qquad (7)$$

Therefore the total unit stress in the plate at any section is given by

$$S = 3.4\ H \pm \frac{0.053\ PH^2}{DT} \qquad (8)$$

It is evident from Equation (8) that the stress due to weight of stack above the section may be neglected up to a height of over 400 ft. with an error of less than 1 per cent.

The weight of the lining has been neglected as it is usually carried by the foundation. In special cases it may be carried on angles riveted to the shell. In such cases the weight should of course of included.

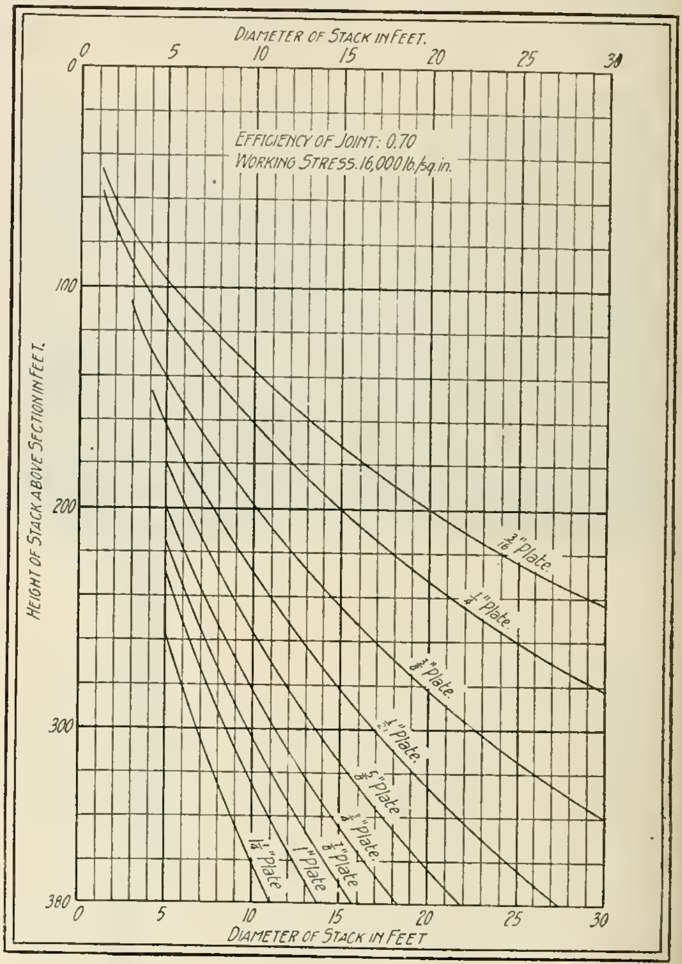


Fig. 3—Thickness of Plates.

Taking P as 20 lb. per square foot, f as 16,000 lb. per square inch, and E for double-riveted joints as 0.70, Equation (6) gives the safe minimum thickness of plate for double-riveted horizontal joints as,

$$T = 0.0000947\ H^2/D \qquad (9)$$

Taking E as 0.50, we have for the safe minimum thickness of plate for single-riveted horizontal joints,

$$T = 0.0001326\ H^2/D \qquad (10)$$

Equations (9) and (10) have been plotted as shown in Figs. 2 and 3. These diagrams give the safe minimum thickness of plate to resist the moment due to wind pressure for any given height and diameter.

Example: Determine the thickness of plate for a stack 16 ft. in diameter with double-riveted horizontal joints, with a height of 240 ft. above the section.

Enter Fig. 2 with the diameter at the top, and follow down the vertical line through 16 till the height, 240 ft., is reached, and read 3/8-in. plate as the thickness required.

For permanent structures 1/4-in. is recommended as the minimum thickness of plate to be used at any time, though 3/16-in. plate has been used for the upper 30 ft. of some comparatively temporary stacks.

Thus starting with 1/4-in. plates at the top, the diagram gives the distance down from the top at which a change of thickness is required. The diagrams are arranged to read from the top downward to correspond with the method of designing. The design is carried in this way from the top down to the top of the bell section. It is customary to use plates for the bell section 1/16-in. thicker than the plates immediately above the bell. These plates are placed vertical with butt joints and single outside straps, though in small stacks the bell section is often built up of circumferential plates.

In stacks of large diameter, the thin plates of the upper sections may require stiffening to guard against lateral collapse. This is usually done by riveting rings made up of angles on the inside of the stack.

It is interesting to note that some engineers recommend that the bell section be made 1/7 the total height above the foundation and that the diameter of the bell at the foundation be 1½ to 2 times the diameter of the stack. These proportions are pleasing to the eye. The development of modern æsthetic taste cannot be ignored entirely by the designer. His stack should be structurally secure and also well proportioned. A neat cornice at the top of the stack is also desirable because of these considerations.

### Minimum Size of Foundation.

First Solution: As the kern for a circular section is D′/4, the resultant of the weight of the stack, stack lining, foundation, and wind pressure must cut the base at a point not greater than D′/8, as shown in Fig. 1 (a). Therefore equating the resisting and overturning moments,

$$(W_c+W_l+W_f)D'/8 = \tfrac{1}{2}\cdot 20\cdot DH(H+h) \qquad (11)$$

or

$$D' = \frac{80\,DH(H+h)}{W_c+W_l+W_f} \qquad (12)$$

which gives the minimum diameter of foundation that will insure compression over all portions of the base.

If h be neglected as being very small in comparison with H, and in like manner $W_c$ and $W_l$ be neglected as being small as compared with $W_f$, an approximation which will evidently give values for D′ which are on the safe side, the expression for D′ may be simplified to,

$$D' = 80\,DH^2/W_f \qquad (13)$$

But $$W_f = \tfrac{1}{4}\cdot\pi D'^2\times h\times 150 = 117.8\,hD'^2 \qquad (14)$$

Setting this value of $W_f$ in equation (13) and solving,

$$D' = 0.879(DH^2/h)^{1/3} \qquad (15)$$

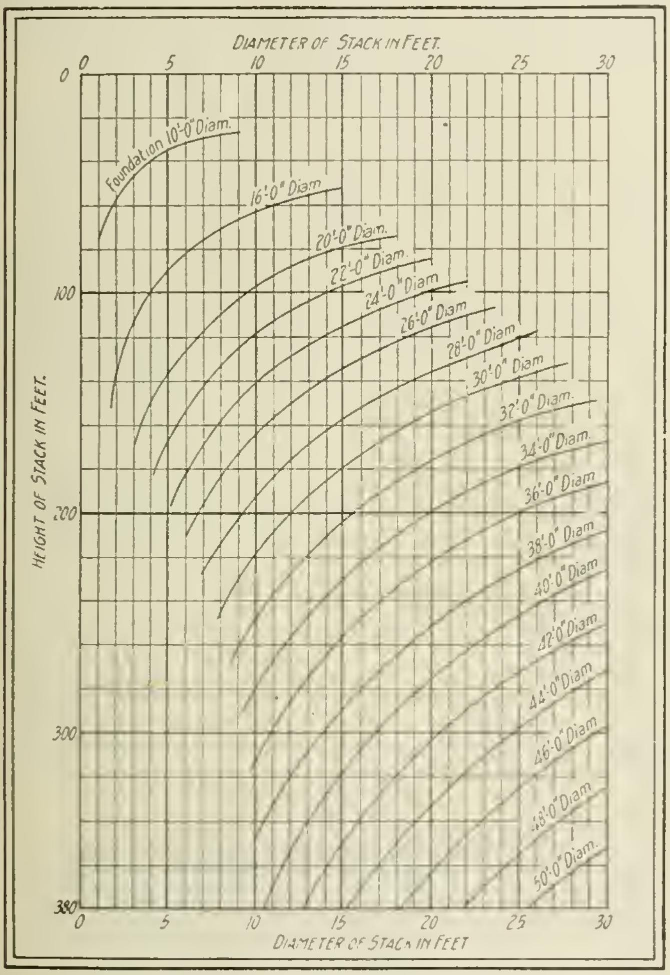


Fig. 4—Diameter of Foundation.

If h be taken as equal to 0.4 D′, a common proportion,

$$D' = 1.14\,(DH^2)^{1/4} \qquad (16)$$

Equation (16) will usually give a sufficiently accurate value for D′, though in some cases it may be desirable to make an exact solution by means of Equation (12) after the value from Equation (16) is obtained.

Equation (16) has been plotted in Fig. 4 so that the minimum diameter of foundation for any given height and diameter is easily obtained.

Example: Determine the minimum diameter of concrete foundation for a stack 15 ft. in diameter and 175 ft. high, assuming that the height of the foundation is 2/5 the diameter. Enter Fig. 4 with the diameter, follow down vertical line through 15 till the height of 175 ft. is reached and read 30 ft. as the required diameter.

Second Solution: The overturning moment at the top of the foundation is

$$M = 10\,DH^2 \text{ ft. lb.} \qquad (17)$$

The weight of the foundation, as found before, is

$$W_f = 117.8\,hD' \qquad (18)$$

Taking moments about an axis tangent to the leeward side of the foundation, and neglecting the resisting moment due to $W_c$ and $W_l$ as small compared with Equation (17), the resisting moment is

$$M = W_f D'/2 = 58.9\,hD'^3 \qquad (19)$$

If a safety factor of 2 be taken, Equation (19) becomes

$$M = 29.45\,hD'^3 \qquad (20)$$

Solving Equations (17) and (20),

$$D = 0.6976(DH^2/h)^{1/3} \qquad (21)$$

If h be taken as 0.4 D′ again, we have,

$$D' = 0.960(DH^2)^{1/4} \qquad (22)$$

It is interesting to note that for a safety factor of approximately 2¼, the two solutions give identical results.

In both solutions the additional surface in the bell has been neglected because it is not only small and has a short arm, but also is usually somewhat protected so that the wind pressure would be less upon it than upon the stack above.

The friction of the soil on the sides of the foundation, which would tend to retard overturning, has been neglected in the above solutions as in some cases the foundation may be placed almost entirely above the surface of the ground. Where the foundation is placed below the ground surface, some saving in volume may be effected by building the foundation as the frustum of a cone with the larger base at the bottom.

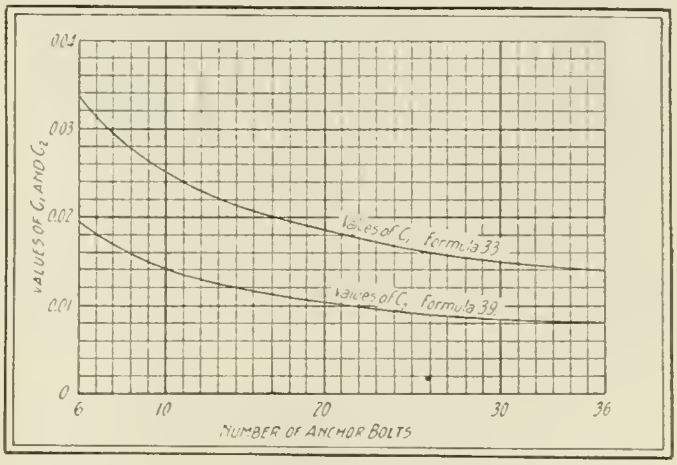


Fig. 5.

The result obtained by the above solutions insures a design secure against overturning, but the design must be investigated for bearing power of the soil also. As the resultant falls within the kern of the section of the base, the maximum direct pressure on the soil is

$$F = \frac{2(W_c+W_l+W_f)}{0.7854\,D'^2} \qquad (23)$$

which must not exceed the safe bearing power of the soil.

### Minimum Size of Anchor Bolts.

First Solution: If in Fig. 1 (b), A—B, the gravity axis of the section of bolt circle, be assumed as the axis about which rotation occurs then the bolts on the windward side will be in tension and the stress in each bolt will vary as its distance from the axis, or the resisting moment of each bolt will vary as the square of its distance from the axis. A stack base containing 12 bolts is shown in Fig. 1 (b). Under these conditions bolts 1, 2, 3, 4, and 5 are in tension. The resisting moment, then, of the group of bolts is:

$$M = t\Sigma x^2 = t[(\tfrac{1}{2}B \sin 30^\circ)^2 \times 2 + (\tfrac{1}{2}B \sin 60^\circ)^2 \times 2 + \tfrac{1}{2}B)] = t\,[2(0.25) + 2(0.75) + 1]\,B^2/4 = 0.75\,B^2t \qquad (24)$$

The moment due to wind pressure is

$$M = \tfrac{1}{2}PDH^2 \qquad (25)$$

therefore

$$t = M/\Sigma x^2 = PDH^2/1.5\,B^2 \qquad (26)$$

The stress in bolt 3, which will be the maximum stress in the group of bolts, is

$$tB/2 = PDH^2/3B \qquad (27)$$

If the fiber stress in a bolt be taken as f, then equating actual stress in bolt 3 to the allowable stress,

$$0.7854 \times f \times b^2 = PDH^2/3B \qquad (28)$$

Solving for b,

$$b = 1.538\,H(PD/fB)^{1/2} \qquad (29)$$

Taking P as 20 lb. per square foot and f as 15,000 lb. per square inch the diameter of anchor bolt for a group of 12 bolts is

$$b = 0.0238\,H(D/B)^{1/2} \qquad (30)$$

For the general case of n number of bolts it may be shown that $\Sigma x^2 = nB^2/16$, then equating actual to allowable stress in outermost bolt as before, we have

$$b = 2.26\,H(PD/nfB)^{1/2} \qquad (31)$$

which gives the diameter of the anchor bolt for any wind pressure, any number of bolts, and any fiber stress.

Equation (31), for a wind pressure of 20 lb. per square foot and a fiber stress of 15,000 lb. per square inch becomes,

$$b = 0.0824\,H(D/nB)^{1/2} \qquad (32)$$

This may be written in the form,

$$b = C_1H(D/D)^{1/2} \qquad (33)$$

Values for $C_1$ were computed for number of bolts varying from 6 to 36 and the values plotted in Fig. 5.

Example: What diameter of anchor bolt is required for a stack 16 ft. in diameter and 175 ft. high, if 15 bolts are used in a bolt circle 25 ft. in diameter?

From Fig. 5 the value of $C_1$ for 15 bolts is found to be 0.0212. Substituting this value in Equation (33), it is found that a bolt 2.96 or say 3 in. in diameter is required.

Second Solution: If the stack be assumed to rotate about an axis tangent to the leeward side of the bolt circle, as shown by C-D in Fig. 1 (c), all the bolts but one will be in tension. As before the stress in each bolt will vary as its distance from the axis and the resisting moment of each bolt will vary as the square of its distance from the axis.

$$\Sigma x^2 = [2(0.134)^2 + 2(0.5)^2 + 2(1.5)^2 + 2(1) + 2(1.866)^2 + (2)^2]B^2/4 \qquad (34)$$

or

$$\Sigma x^2 = 4.5\,B^2$$

For the general case of n bolts it may be shown that

$$\Sigma x^2 = 3nB^2/8 \qquad (35)$$

Therefore, solving as before,

$$b = 1.70\,H(PD/nfB)^{1/2} \qquad (36)$$

For the same load and fiber stress as before, for 12 bolts we have,

$$b = 0.0137\,H(D/B)^{1/2} \qquad (37)$$

which is only about 60 per cent of the value given by Equation (30).

Setting the same load and fiber stress in Equation (36), we have,

$$b = 0.04764(D/nB)^{1/2} \qquad (38)$$

Again this may be written in the form,

$$b = C_2H(D/B)^{1/2} \qquad (39)$$

Values for $C_2$ have been plotted in Fig. 5 that the results given by Solutions 1 and 2 might be compared.

Third Solution: From Equation (4) the stress per lineal inch along the circumference at any section is $S' = 0.053\,PH^2/D$. Therefore the stress in each anchor bolt will be S′p, where p is the distance between the bolts in inches. Therefore equating actual and allowable stresses,

$$0.7854 \times f \times b^2 = 0.053\,\frac{PH^2}{D} \times \frac{12\pi B}{n} \times \frac{D}{B} \qquad (40)$$

Solving for b,

$$b = 1.595\,H(P/nf)^{1/2} \qquad (41)$$

For 12 bolts and with same load and fiber stress as before,

$$b = 0.02377\,H \qquad (42)$$

For the general expression for any number of bolts and the same load and fiber stress,

$$b = 0.0823\,H(1/n)^{1/2} \qquad (43)$$

Comparison of Solutions: For a comparison of the solutions, take the case of 12 anchor bolts and assume B equals 3/2D. Then the values for b are:

Solution 1: b = 0.0193 H, from Equation (30).
Solution 2: b = 0.0112 H, from Equation (37).
Solution 3: b = 0.0237 H, from Equation (43).

It is evident that the assumptions made in Solutions 1 and 3 will give stresses which will be too high, while Solution 2 will give stresses which will be too low as it neglects the stress in the bolts on the windward side which exists before the neutral axis of bending becomes coincident with the tangent on the leeward side. The probable true stress, therefore, would appear to lie between the extreme values given by the above solutions.

It is interesting to note that if B equals D, Solutions 1 and 3 give the same result.

Anchor bolts should always be upset at the threaded end and should extend nearly through the foundation with a nut and washer at the lower end.

### Riveting.

A small rivet spacing should be used for all joints to insure tightness, being not less than 2.5 times the diameter of the rivet or more than 16 times the thickness of the plate. A single-riveted lap joint is commonly used for the vertical joints, while a double-riveted lap joint is used for the horizontal joints. It is very desirable that the horizontal joints should be water-tight, that the water running down the inside of the stack, which becomes strongly acid, may not get into the joints and cause corrosion, and also that the water may not run through the joint and give the outside of the stack a very untidy appearance.

It will be found that the above recommended rivet spacings and joints will give ample strength at any section for direct stress or shear.

The connection of the shell to the base plate must be carefully investigated to insure a sufficient number of rivets to transfer the stress from the plates to the base plate. Equation (4) gives the stress per lineal inch along the circumference for a diameter D, therefore the stress per lineal inch at the base plate will be,

$$S' = 0.053\,PH^2/B \qquad (44)$$

From this equation the necessary rivet spacing is easily obtained.

### Base Plate.

The base plate is commonly of cast iron, made up of sections from 20° to 180° of arc in length, which are firmly bolted together. The shell is riveted to the base plate and the anchor bolts pass down through it. Another form of base plate consists of a ring of angle iron around the inside of the shell, with short pieces of angles, placed vertically and in pairs that the anchor bolt may pass down between, riveted to the outside of the shell.

Each section of the cast base plate may be designed as a beam with a uniformly distributed load due to the wind pressure transferred through the plates, and two or more reactions due to the anctor bolts. The width of the base plate must be investigated also that the allowable bearing power of the concrete foundation be not exceeded.

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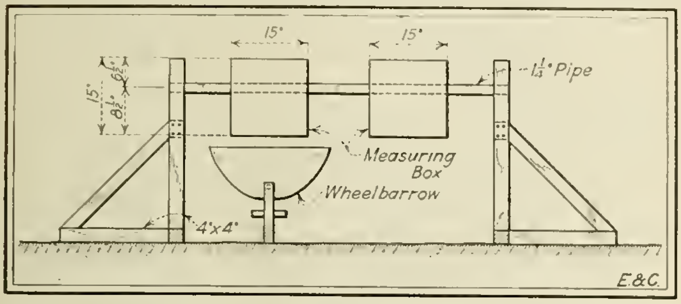
An international competition is to be held to select an architect for the Federal Parliament House at the new capital city of Canberra in Australia. The government will receive the designs in either London or Melbourne until Jan. 31, 1917. The Federal Capital Director of Design and Construction is Walter Burley Griffin, whose address is Department of Home Affairs, Federal Capital Office, 84 William St., Melbourne, Victoria.

## MEASURING CONCRETE MATERIALS IN BOXES THAT DUMP INTO WHEELBARROWS.

Where accurate proportioning of concrete ingredients is desired, many engineers object to measuring them by wheelbarrow loads. The accompanying drawing shows how the problem has been satisfactorily solved.

Two measuring boxes, each holding, say, 1½ cu. ft., are mounted so as to revolve on an axle consisting of 1¼ in. pipe. The pipe is supported by a wooden horse at each end. The pipe passes through the measuring box above its center of gravity, so that it will not revolve and discharge its load unless it is pushed over by the workman. Then it discharges into a wheelbarrow beneath. This measuring and loading device can be set up close to a stack pile of sand, and a similar device can be placed close to a stack pile of gravel or stone. The slightly increased lift involved in shoveling into the box instead of into the wheelbarrow direct is offset by the reduction in lost time involved in waiting for barrows to arrive.



Concrete Material Measuring and Loading Device.

This revolving box scheme might be used on a larger scale to measure sand and stone drawn from bins.

## DEVICE FOR RAPID LOADING AND UNLOADING OF LUMBER.

A motor truck equipped with a special quick roll body is used by the Hawkeye Lumber Co., Cedar Rapids, Ia., for hauling lumber. The truck is a 2-ton Jeffrey Quad, made by the Nash Motor Co., Kenosha, Wis.

The body is built to load and unload any goods which may be put on rollers with surprising dispatch. It is, however, especially adapted to the lumber business. As its name implies, it is equipped with rollers which support the load on the truck bed.

The tail end of the body is equipped with a stout roller, supported by two cast steel bearings. The roller is operated by a hand lever and a double acting pawl working in a ratchet keyed to the end of the roller. By simply manipulating this handle one man can unload several tons of lumber in as little as 50 seconds' time.

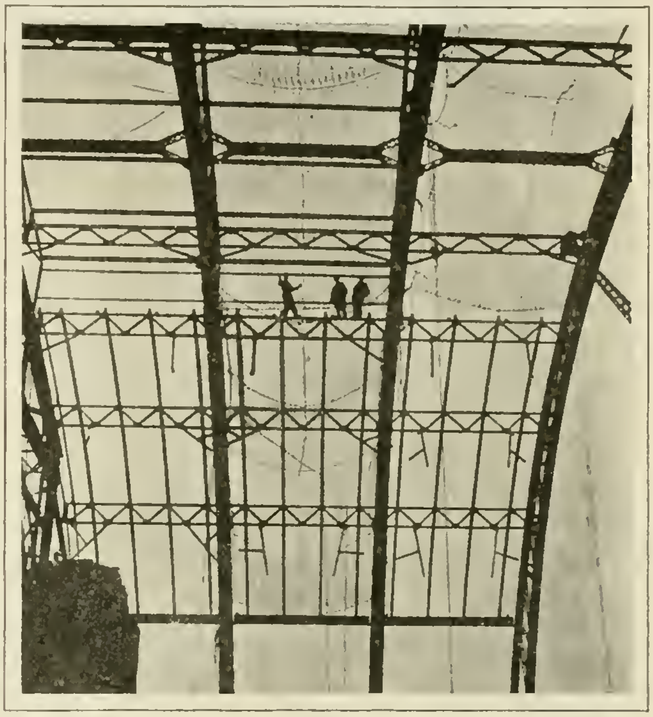
Motor Truck With Quick Roll Body.

Loading lumber on to the truck is equally as easy. While the truck is out with one load, the men in the yard pile the next load on a pair of trestle-trees built about an inch higher than the body of the truck. The latter on its return simply backs under, knocks the first support from underneath and the load slides over the rollers and is locked securely on the truck by the double acting pawl.

## SAFETY NETS IN STRUCTURAL WORK.

The Department of Factory Inspection of the State of Illinois has found that orders calling for temporary scaffolds for the protection of the men engaged in the erection of steel and iron structures, in many instances were impracticable and involved unnecessary expense. The department after much investigation and study has decided that by the use of safety nets the men will be given much better protection than by wooden planking, and accordingly is ordering the use of these nets on all classes of structural work, where planking would be impracticable.

The safety nets are similar in character to those employed for the protection of circus performers. It is claimed for them that they are inexpensive, easily adjusted and removed, and readily transported from one job to another. The nets are suspended beneath points where the men are working. Steel wire netting was not satisfactory, but rope netting was found to fill the want. The nets are 20 by 40 ft. and consist of ⅝ in. manila rope, with ¾ in. border. The mesh is 6 by 6 in. The borders are fitted with loops so that the nets can be readily attached to various points and shifted from place to place. When the job is completed the nets are rolled up for storage or shipment.



Safety Nets as Used by Morava Construction Co. in the Erection of the Recreation Building and Shelter House at Chicago.

The accompanying illustration, from the recently issued report of the Chief State Factory Inspector, shows the arrangement of nets as made by the Morava Construction Co., Chicago, in the erection of the recreation building and shelter house at the municipal pier of Chicago. This picture shows removal of safety rope netting upon completion of steel erection and painting.

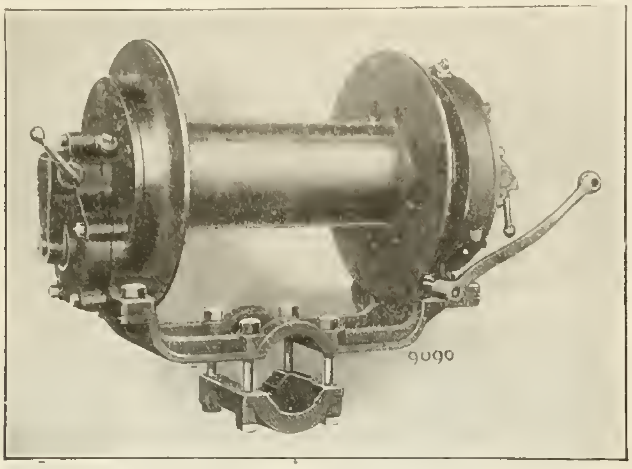
## A NEW MODEL LITTLE TUGGER HOIST.

For the use of those who prefer manila rope to wire rope for light hoisting and hauling, the Ingersoll-Rand Co., 11 Broadway, New York City, has brought out a new model Little Tugger Hoist, which is designated No. 11.

The square piston, reversible driving engine, automatic lubrication, enclosed gearing, drum release clutch and worm operated band brake are essentially the same as in the No. 1 model, which was described on page 281, Engineering & Contracting, Sept. 16, 1914. The main differences are in the diameter and length of the drum, the width of the flanges and, necessarily, the main frame and overall dimensions.

The new No. 11 Little Tugger has a hoisting drum 7 in. in diameter by 17 in. long with 5-in. flanges. This accommodates 300 ft. of ⅞ in. manila rope. The maximum capacity of this hoist is conservatively rated at 600 lb. The weight of the hoist itself is 358 lb. It is 21½ in. long, 31¼ in. wide and 23 in. high.

Like the No. 1, the No. 11 Little Tugger is built for operation both by compressed air and steam. The standard clamp fits a 4½-in. diameter column or pipe, but by removing the clamp the hoist can be readily bolted directly to any convenient support, timber, flooring, etc.



New Model Hoist.

Although designed primarily for underground work it can be used by the manufacturer for all around hoisting, hauling and handling in mines, tunnels, quarries and industrial plants.

## PORTABLE MIXERS SUPPLEMENT DISTRIBUTING TOWERS.

Portable mixers were used to supplement the distributing towers in the construction of a large warehouse at 39th and Canal Sts., Chicago, for the Chicago Junction Ry. Co.

The building is being constructed by George A. Fuller Co., who are using three distributing towers as the principal means of conveying the mixed concrete. For mixing the large quantity of concrete required in the footings and walls for the street foundation and the footings for the numerous central columns, there were used two of "The Standard" low charging mixers, made by the Standard Scale & Supply Co., Chicago. One of these was of 10 cu. ft. capacity and the other of 16 cu. ft. capacity. After the street foundation walls were completed the mixers were mounted directly on these walls for supplying concrete for central foundation footings. When placed in this manner the mixers discharged directly into hoppers from which the concrete was gated into carts for distribution. The mixers were moved along the walls as the work progressed, so that it was not necessary to wheel any of the concrete a great distance. In the accompanying illustrations, Fig. 1 is a panoramic view showing two of the towers and one of the concrete mixers (in the circle) mounted on the wall at the left.

Portable Mixer in Construction of Warehouse, Chicago.

## PERSONALS.

Bert Paynter has been appointed county road engineer of Anderson County, Kentucky.

A. W. Kutsche & Co. have opened offices in the Ford building, Detroit, Mich., and will carry on a general building business.

Edmund L. Hiatt has resigned as chief engineer of the Ray Consolidated Copper Co., to become manager of the Arizona Ray Copper Co.

C. R. Thomas, Wilmington, N. C., has been appointed division engineer of the State Highway Department of Kentucky, succeeding O. S. Canning, resigned.

Edward L. Dufourcq has removed his offices from the Produce Exchange building to No. 18 Broadway, New York City, where he will continue his practice as consulting mining engineer.

Cleveland A. James, recently with the Lehigh Valley R. R., in charge of Buffalo terminal construction, has located in Room 920, Fidelity Trust building, Buffalo, N. Y., as consulting engineer.

J. A. Shepard, superintendent of terminals at Kansas City, Mo. for the Missouri Pacific R. R., has been elected president and general manager of the Trans-Mississippi Terminal Co. of New Orleans.

Arthur L. Luedke has resigned as assistant division engineer of the Wisconsin Highway Commission at Milwaukee, Wis., to accept a position as engineer-economist in the U. S. Office of Public Roads. Mr. Luedke's duties will be along studies in road economics and costs.

G. W. Stickney has been appointed chief engineer of the Rivers and Lakes Commission of Illinois. Mr. Stickney formerly was designing engineer of the paving department of Syracuse, N. Y. He also has had experience on the Metropolitan Waterworks of Boston, Mass., and on the New York State Barge Canal.

Alfred Craven, chief engineer of the Public Service Commission for the First District of New York City since Oct. 1, 1911, on Nov. 1 becomes consulting engineer to the Commission at a salary of $12,000 per year. The position was created for the purpose and in recognition of Mr. Craven's valuable services to the city and to the Commission. The Commission designated Daniel L. Turner as acting chief engineer at a salary of $12,500. Mr. Turner, who is now deputy engineer of subway construction, has at times acted as chief engineer.

The Alabama Technical Association has been formally organized at Birmingham, Ala. The association includes life members of the five national engineering societies: The American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining Engineers, and the American Chemical Society. The movement for the state organization was started by H. S. Geismer, Frank H. Crockard, S. H. Lewis, Martin J. Lide, Julian Kendrick, H. M. Gassman, F. G. Cutler, Priestly Toulmin and W. E. Mitchell. The proposed constitution and by-laws of the association have been drawn by a committee composed of Martin L. Lide, F. G. Cutler and H. S. Geismer.

## OBITUARY.

William L Price, of Price & McLanahan, Architects, Philadelphia, Pa., died Oct. 14 at his home near Maylan, Pa., aged 54 years. Mr. Price had been ill about two weeks from a nervous breakdown and his death was unexpected. He designed many of the largest hotels and other prominent structures in this country.

Lawrence M. Thacher, for the past ten years a member of the engineering department of the Georgia Ry. & Power Co., died Oct. 6 at a hospital in Atlanta, Ga. He was a graduate of the Massachusetts Institute of Technology and for fourteen years had been engaged in engineering work in the south. He was for several years resident engineer in charge of extending the Florida East Coast Ry. to Key West. At the time of his death he was president of the Atlantic section of the Engineering Association of the South.

Virgil G. Bogue, one of the foremost civil engineers of America, died Oct. 14 on the steamship Esperanza, while en route from Mexico to New York City. Mr. Bogue was born in 1846 and was graduated from Rensselaer Polytechnic Institute in 1868. His first work was as assistant engineer at Prospect Park, Brooklyn, N. Y. Later he became assistant engineer of the Obiju Ry. in Peru and then manager of the Trajille Ry. of Peru. He was assistant engineer of the Northern Pacific R. R. and had charge of the construction through Idaho and Washington. In 1886 he became chief engineer of the Union Pacific R. R., resigning this position in 1891 to take up private practice in New York City as consulting engineer. In the latter capacity he has been connected with many notable railway undertakings. When the Western Pacific Ry. was started Mr. Bogue became vice-president and chief engineer, serving in these capacities from 1905 to 1909.

## INDUSTRIAL NOTES.

The Nordberg Mfg. Co., Milwaukee, Wis., builders of steam and electric hoists, Corliss engines, etc., announce the appointment of H. W. Dow as sales manager. Mr. Dow has been associated with the Nordberg Mfg. Co. in the engineering and sales departments for twelve years.

The Gramm-Bernstein Co., of Lima, O., makers of the motor truck bearing its name,. has been reorganized, and a new company to be known as the Gramm-Bernstein Motor Truck Co. has been incorporated with a capital stock of $4,000,000 divided into $3,000,000 common shares and $1,000,000 preferred shares. The officers of the new company will be as follows: M. Bernstein, president and treasurer; B. A. Gramm, vice-president and general manager; H. O. Bentley, secretary and legal adviser; R. H. Spear, director of sales.

With the co-operation of Harvard University and the Massachusetts Institute of Technology, the Barber Asphalt Paving Co. has established at these institutions a fellowship for research in asphaltic materials and their uses. The fellowship is to be known as "The Clifford Richardson Fellowship." Mr. Richardson is a distinguished alumnus of Harvard and this, taken in connection with his great contributions to asphaltic highway construction and his work in the chemistry of bitumens, makes the designation of the fellowship particularly appropriate. The appointment of the incumbent of the fellowship and the choice of subjects for investigation, as well as the disposition to be made of the results of such investigations as may be undertaken, are to be decided by the institute faculty or the joint committees of the university and the institute having control of engineering work.

Roads and Streets Monthly Issue
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Halbert P. Gillette, *President and Editor*

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## AN OPEN LETTER TO THE CHICAGO TRIBUNE ON THE FEDERAL AID ROAD LAW.

In yesterday's issue of the Tribune you class the federal appropriation for road work as a piece of "pork barrel" legislation. I can hardly believe that you are familiar with the provisions of the new law under which the federal government is to render financial aid to the states in building roads.

No state can secure its share of the $75,000,000 appropriation without matching every dollar that the government puts up with a dollar of its own. This alone assures protection against the "pork" feature, and differentiates this road bill from the river and harbor bills that have so often proved to be mere money grabs.

Not until certain states began to pass similar road laws, under which the state at large aided the local communities in financing road improvement, did American highways deserve the name of good roads. One by one the states have been falling into line, passing state aid road laws, and thus getting their first taste of good roads.

The economic argument in favor of state aid is this: Roads, like railways, are not purely local institutions, for the entire country profits directly and immediately through their improvement. If, then, roads are not purely local in their effect upon industrial progress and upon the cost of living, it becomes the part of statesmanship to provide at least part of the money for road improvement from the funds of the state at large.

Whatever be the theories that may be raised against such an argument, one fact stands shingingly forth: No state in America or Europe ever secured a substantial mileage of satisfactory roads until roads were built with money secured from other sources than local assessments.

Were America entirely centralized as to government, all of America would be "the state," and then no student of public economics could be found to oppose federal aid in road building.

By the chance of evolution, America is a state federated —a union of states. The central government may now exercise fewer functions than do the corresponding governments of Europe, but this does not alter the general economic law that it profits all the country to develop its public highways with capital secured, at least in part, from other than local sources. What the states have individually found wise to do—share the burden of road costs with the counties and road districts—the nation at large will also find wise to do.

More than 10 years ago the writer associated himself with other civil engineers and men of public spirit in an effort to secure a federal aid road law. Neither political faith nor place of residence affected any of us. We belonged to both of the great parties and when we went to Washington, D. C., we represented every section of America. We failed in our effort then, but we have kept up the fight for federal aid until at last some measure of success has rewarded our efforts. I doubt not that a Republican administration would have done what the Democratic administration did, for the arguments in favor of federal aid in road building have become well nigh invincible. The only real opposition to arguments was to be found in two phrases—"pork barrelism" and "paternalism." But we killed the first—"pork barrelism"—by providing that every state must share equally with the government the cost of road building; and the second—"paternalism"—died a natural death, for it never was more than a hybrid verbalistic bugaboo of doubtful ancestry and incapable of propagating its kind.

After studying the federal road aid law, I believe the Tribune will join us in the effort always to keep "pork barrelism" out of the law, for it certainly is not in the law now. And I trust that we may have the active support of your great influence in furthering the development of a highway system that will do more toward reducing the high cost of living than any single thing that can be named.

Yours very truly,
Halbert P. Gillette,
Editor, ENGINEERING and CONTRACTING.
Oct. 10, 1916.

## THE "CITY AID" PLAN OF STREET IMPROVEMENT AND ITS EFFECT ON HEALTH AND ECONOMY.

Reasoning by analogy is apt to lead to error unless the analogous things are fundamentally alike. It has been well established that country road improvement invariably lags behind economic necessity wherever the entire cost of the road improvement is assessed against the abutting property owners. Realization of this fact leads first to "road district aid," then a "county aid," then to "state aid" and, finally, to "national or federal aid" in road building. But as yet we have not generally awakened to the fact that there is so close an analogy between country roads and city streets that, to secure adequate and general improvement in city streets, the abutting property owners must have "city aid."

City engineers should universally determine the types of pavement required, design and supervise the construction, and the city at large should bear half, if not three-fourths, the cost of construction of all pavements within the city limits. The old theory that the abutting property owner is the sole beneficiary from street improvement will scarcely be brought forward even by the most pronounced advocate of individualism.

In many towns a few skinflint property owners or absentee landlords block every effort to provide up-to-date pavements on many streets. Frequently the majority of property owners are forced to give in to the minority, to get any pavement at all, and there results a "cheap and nasty" pavement that disgraces the entire neighborhood for years. But it is not so much the disgrace of a shabby, rutty, dirty street as it is the loss of economy and health that should engross the attention of city dwellers.

Doctor Flexner, head of the Rockefeller Institute, said in the New York Medical Journal, July 22, in speaking of infantile paralysis:

> Mere drying of the secretions is not protection; on the contrary, as the dried secretions may be converted into dust, which is breathed into the nose and throat, they become a potential source of infection.

Doctor Neustaedter, of the New York University, emphatically affirms that dust is the greatest disseminator of infantile paralysis. He says:

> "I advise a thorough scrubbing of the floors and frequent flushing of the streets and sidewalks. We must remember that people spit on the walks and children play there."

It is now pretty generally conceded that diseases of the respiratory organs—pneumonia, tuberculosis, "colds" in general, etc.—are mainly transmitted by means of dust. Doubtless, also, many other diseases are similarly transmitted. A clean street is possible only where the pavement is smooth. A smooth pavement permits proper sweeping, and, best of all, flushing. But how many of our pavements are smooth? Those who ride in automobiles know that a very small percentage of the pavements in any city—save a few rare and notable exceptions—are even tolerably smooth.

Already there is a cry for cleaner streets, but how many taxpayers realize that this is tantamount to an asking for smooth pavements. If many of them did realize it, and if they know something of the history of road improvement, they would cease their cry for cleanliness until they had first secured a revision of city ordinances and methods of assessing street improvements. They would aim first to get "city aid" in building streets, and the placing of all authority as to street work in the hands of the city engineer. Then there could be effectively started a campaign for good, smooth pavements throughout the city. And, finally, having obtained smooth pavements, freedom from dirt and dust could be readily secured.

Little at this time need be said about the saving in delivery costs that will result when all pavements are smooth. The wear and tear on tires and motors, resulting from poor pavements, is already causing great expense in every city, and the expense is increasing annually in geometrical proportion. This expense burden is upon all residents of every city, and it alone would justify the contention that the city at large should bear most of the cost of street paving.

Let city engineers adopt for a slogan, "City aid in street improvement." Highway engineers, by incessantly calling for "state aid in road work," have at last aroused the general public to adequate appreciation of the desirability of relieving the farmer of a large part of the cost of road building. Similarly the "abutting property owner" in the city must be relieved by the city at large. Give him "city aid" if you wish smooth, clean pavements, with consequent economy in transportation and a lower death rate.

## AN ORGANIZATION TO CO-ORDINATE SCIENTIFIC RESEARCH.

Scientific research, or the systematic investigation of nature, is now conducted by a multitude of individuals, societies, companies and government bureaus or departments. The question has been raised whether it may not be possible so to co-ordinate all these efforts as to advance our scientific knowledge at an even greater speed. The National Academy of Science has appointed a National Research Council whose object is to co-ordinate research work in America in order to secure the most efficient solutions of industrial and military problems. The Engineering Foundation has placed about $15,000 yearly at the disposal of the National Research Council, and a movement has been started to raise more funds.

The chairman of the council is the celebrated astronomer, Dr. George E. Hales, director of the Mt. Wilson observatory in California. Pure science is represented on the council by five noted scientists:

Edwin G. Conklin, professor of zoology, Princeton University.

A. A. Noyes and L. H. Baekeland, professors of chemistry, the former of Massachusetts Institute of Technology.

A. A. Michelson, professor of physics, University of Chicago.

M. I. Pupin, professor of electricity, Columbia University.

Medicine and surgery are represented on the Council by four physicians and surgeons:

Dr. Simon Flexner, director of the Rockefeller Medical Institute.

Dr. William H. Welch, president of the National Academy of Science.

Dr. William C. Gorgas, surgeon general of the U. S. Army.

Dr. Victor C. Vaughn, past president of the American Medical Society.

In addition to Prof. Pupin, above named, there are eight engineers from the national engineering societies and colleges:

Clemens Herschel, president of the American Society of Civil Engineers.

Charles F. Rand, president of the United Engineering Society.

John J. Carty, past president of the American Institute of Electrical Engineers.

C. E. Skinner, director of the research laboratory of the Westinghouse Co.

W. R. Whitney, director of the research laboratory of the General Electric Co.

Gano Dunn, president of the J. G. White Engineering Corporation.

W. F. M. Goss, dean of engineering, University of Illinois.

R. H. Chittenden, dean of Sheffield Scientific School, Yale.

The army, navy and other branches of the government are represented by eight men: Maj.-Gen. William Crozier, Lieut.-Col. George O. Squier, Chief Constructor David W. Taylor, Dr. S. W. Stratton, Van H. Manning, Prof. Charles F. Marvin, Dr. William H. Holmes and Dr. Charles D. Walcott.

The remaining 12 members of the Council are: Dr. John A. Brashear, Dr. W. W. Keen, Prof. E. C. Pickering, Prof. Theodore W. Richards, Prof. R. A. Millikan, Ambrose Swasey, Dr. Elihu Thomson, Dr. C. R. Van Hise, Dr. J. M. Coulter, Prof. Raymond Pearl, Prof. M. T. Bogart.

To the present total of 38 members of the National Research Council other members will be added as the needs of the work may require.

Although engineers are fairly well represented on the Council, the names of several more engineers occur to us as desirable additions to a Council whose primary object is to co-ordinate scientific research. Perhaps a more important omission is the names of professional inventors, of whom not one appears among the 27, if we except Mr. Skinner and Mr. Whitney, the two directors of great research laboratories. Surely men like Edison, who have conducted extensive experimental researches, are among the best qualified to advise on matters such as this Council will act upon.

It may be questioned, of course, whether so heterogeneous a body as this Council of 38 can so act as to accomplish its aims. The experiment, however, is well worth trying. At any rate it adds one more noteworthy attempt at "getting together" for the good of society.

## ELIMINATE DECEPTIVE COSTS OF ROAD MAINTENANCE.

Costs of road maintenance in New York State have been repeatedly quoted to prove the high upkeep charges on certain classes of roads. Some time ago we pointed out that the entire rebuilding of old roads to enable them to stand up under automobile traffic is either not a maintenance cost at all, or, if so regarded, is not applicable in estimating the maintenance cost of modern roads. In another column an article by Mr. Daniel T. Pierce brings out the fact that engineering and inspection costs ("overhead charges") for road maintenance in New York state bear no relation whatever to the direct cost of labor and materials. The "overhead charges" seem to be arbitrarily assigned to the different roads, and therefore tend to obscure the actual maintenance costs on individual roads.

Eliminating "engineering and inspection" charges, Mr. Pierce shows a very significant fact, hitherto obscured, namely, that the average cost of maintaining 12 roads constructed with natural asphalt binder has been $213 per mile per annum, as compared with $385 per miles per annum for 12 roads constructed with residual asphalt binder.

Quantitive data to establish such a fact have hitherto been insufficient to carry complete conviction. Hence, we regard this article by Mr. Pierce as among the most important contributions to the literature of road maintenance.

We take this occasion again to insist that until the states adopt better methods of prorating "overhead charges," as well as a more scientific distinction between road improvement and road repairs, the road maintenance costs published in most of the state highway reports will remain highly misleading to engineers and even more so to taxpayers.

## THE DISINTEGRATION OF CERTAIN CONCRETE ROADS AND ITS LESSON.

The concrete roads of Wayne County, Michigan, have been so assiduously advertised as being the last word in road construction that it will surprise a good many highway engineers to hear that extensive resurfacing of some of them is under way. One of the roads has recently been resurfaced with a 3-in. layer of 1:1.5:2.5 concrete reinforced with triangular mesh wire. Other roads have required patches covering large areas.

The sooner the advocates of concrete roads for any and all conditions come to a realization that there are limitations to the life of concrete under heavy traffic, the better will it be for all concerned. Once a concrete surface begins to crumble, it is exceedingly difficult to prevent rapid enlargement of the abraded area, for a thin layer of new concrete placed upon the old does not make a satisfactory patch. Concrete in this respect differs from macadam and from asphalt.

Almost any pavement surface, save waterbound macadam, will hold up under the traffic of pneumatic tired vehicles. But under heavy motor trucks, particularly those hauling steel tired trailers, concrete is no more immune from wear than any other kind of pavement; indeed it is less resistant than some types.

If it be conceded that, under the heavy traffic that is fast developing on many roads, every kind of pavement must suffer some degree of wear, then it is patent that the engineer must give considerable thought to the means available for patching and repairing, and to the relative costs of such maintenance.

We believe that it will become increasingly evident that all roads subject to heavy traffic must be built in two layers—a cheap base to distribute the concentrated wheel load and a more expensive wearing surface to resist the direct impact and abrasion of traffic. The wearing surface to be easily patched must not be integral with the base. This is a return to first principles in road building which is certain to occur.

## SEPARATE ROADWAYS FOR MOTOR TRUCKS.

What is perhaps the first separate road for motor trucking is now being built by Los Angeles county, California. The road is 13.3 miles long from Los Angeles to the harbor at San Pedro. It consists of a 5-in. base of disintegrated granite, 40 ft. wide, forming a waterbound macadam on the center of which is laid 8 in. of 1:2:4 concrete, 24 ft. wide. A bituminous carpet covers the concrete.

As motor trucking becomes increasingly important we may confidently look to see a rapidly growing mileage of roads built exclusively for such traffic, in and about all cities of considerable size. We say "in" as well as "about," for inevitably certain streets of every large city will be given up to slow-moving heavily-loaded vehicles.

Rubber tired motor trucks, especially when not loaded above 750 lb. per in. of tire width, apparently do little damage to the surface of a properly designed pavement, but it is obvious that a thicker pavement base is required for heavy motor trucks than for pleasure cars or light delivery trucks. This fact, coupled with the desirability of separating fast-moving from slow-moving vehicles, makes it desirable to build separate roadways for heavy trucking wherever the density of traffic warrants.

On some of the highways in Louisiana crossing bayous culverts are used primarily to equalize the water level on each side of the embankment. This pipe is laid below the water level and is generally called an equalizer.

## "LOCATING ROADS WITH REFERENCE TO MAINTENANCE."

To the Editor: I have read with much interest the editorial in your issue of Oct. 4 entitled, "Locating Roads with Reference to Maintenance."

I think that your editorial strikes the keynote of sound engineering practice on highway location, and I do not think that many of the points brought out in your editorial are fully appreciated by highway engineers until they have had some actual experience in highway maintenance.

In the course of my personal experience I have twice been tempted to make extensive channel changes where they showed a saving in first cost. In both instances I was inclined at the start to believe that these channel changes —each of which eliminated two steel bridges—would result in a greatly reduced maintenance cost, and in both instances I was bitterly disappointed, as in the case of one of these channel changes the annual damage from erosion during the first two years was considerably in excess of the probable cost of upkeep on the two bridges eliminated by the change. Since that time I have not been in personal contact with this work, but I am advised that the maintenance conditions at both of these places are far from satisfactory.

Yours very truly,
Wm. F. Cocke,
Commissioner, Florida State Road Department.
Tallahassee, Fla., Oct. 12, 1916.

## THE GRANITE BLOCK PAVEMENT.

To the Editor: In your issue of Sept. 6, 1916, on pages 204 and 205, you ran an editorial article under the title "Should Stone Block Pavements Be Longer Tolerated?" and in this article severely arraigned the granite block pavement.

It is very evident the writer of that article is unfamiliar with the modern improved smooth granite block pavement as laid by the engineers of most of the large and many of the smaller cities of the United States. It is a well known fact that the only material known to science and engineers today which is suitable for a modern smooth pavement, and which will stand up longest and at least cost under the most severe traffic is the improved granite block pavement.

Also in direct refutation of the argument that the modern motor truck has eliminated the need for granite I attach herewith a copy of a letter written to Dr. Rowley of Boston by the Law and Traffic Department of the Motor Truck Club of America, definitely stating that after two years of thorough investigation of pavements suitable for motor truck traffic they have conclusively endorsed the modern granite block pavement as being the most serviceable and most acceptable to them of all types of pavement.

We think it is only justice to your subscribers that you publish this letter and also the copies of the letters from the Coal Merchants' Association of New York City, largely using motor trucks; and the Team Owners' Association of New York, largely using horses; and the letter of the Humane Society of New York.

[Lack of space prevents the publishing of these letters.—Editor.]

Not only that, but we attach a copy of a letter written officially by the New York Life Insurance Co., a large owner of office building property in New York, directly endorsing the modern type of granite block pavement even for such a congested office and business section of New York City as lower Broadway.

It does not seem possible your editorial writer has never seen a modern granite pavement, of which millions of yards have been laid in the various cities of the United States in the past six to seven years, but we are often surprised that so many laymen and even engineers ride over modern smooth granite block pavements and fail to recognize them as granite, because they are familiar only with the old style stone block pavements.

A modern granite block pavement is not only just as smooth and even of surface after a very few months' use as the other types of modern pavements, but it is the only paving material in use today to any great extent which is not excessively slippery when wet. With a granite pavement surface under his tires, the truck or auto driver or the teamster can sucessfully move at from 25 per cent to 50 per cent faster speed and with 40 per cent to 60 per cent greater safety, on wet or frosty or snowy days than on any other type of modern pavement.

The statement is also made in your article that stone block pavements are so expensive in first cost that their economic use has never been justified at all, except where traffic is very dense.

If all the costs of administration, material, repair gangs, losses from delays to traffic and breakages due to unevenness, holes, ruts, etc., could be charged up against any pavement, other than granite, it would undoubtedly much overtop the original cost of the granite block pavement which has stood traffic on Main St., Worcester, Mass. (population over 200,000), for 15 years, with an initial cost of only about $3.21 per square yard, and no expense for maintenance due to wear and tear since that original cost, and still in perfect condition, with a probable life, according to Mayor Wright of Worcester, of from 35 to 50 years more, with no maintenance necessary due to wear and tear.

No, this is not a fairy tale, and the best evidence we could offer to the engineers of the United States that this statement is a fact is that the cities of New England and New York State and New Jersey, which have had their officials carefully investigate the facts regarding this Worcester pavement have now followed the lead of Worcester and have laid within the past 10 years several hundred miles of this type of pavement.

Furthermore, the city of Greater New York has consistently laid improved granite block pavements on all its main business streets for the past six years, using asphalt almost exclusively for its residence streets; this attitude on the part of the engineers of the different boroughs being directly the result of their cost experience with the upkeep of all pavement materials.

An investigation of your construction news pages will also clearly show that Boston has just ordered laid almost $500,000 worth of improved granite block pavements; Philadelphia is laying more and more of this type of pavement every year; Cleveland is laying miles of stone block pavements; Chicago and Cincinnati, miles more—Cincinnati having just passed by two-thirds citizen vote an order for a $2,000,000 bond issue for granite block pavements to go on five of her main streets.

The last paragraph of your article also shows a lack of familiarity with the proceedings of recent conventions and road meetings, as the great problem which city engineers everywhere are today studying most carefully is the economic design of a pavement which will stand the constantly increasing weight and speed of modern trucks, granite block up to this time being the only recognized material which all city engineers have found is safe, economic and convenient for service under any and all conditions of traffic and weather.

Finally we want to question your statement that even a very smooth granite block pavement, with cement joints, shows a resistance 60 per cent more than asphalt at 12 miles an hour, unless you qualify it by giving the exact weight of the car used to make this test and admit that the test was made on a perfectly new asphalt pavement—when it was hard, as in cold weather—which had never much heavy traffic and which was not wet at the time the test was made, and that the comparison was made with a cement grouted pavement which was not yet worn down to the normal smooth surface which comes only after months of traffic have been over it.

This test, made with a 6 to 8-ton load on a 6 to 8-ton truck on a warm or slippery day when the asphalt was soft or slippery would show a very marked difference from your figures; to say nothing of the fact that asphalt which will stand heavy and continuous traffic is quite expensive initially and very expensive to maintain.

It is not our desire to criticise statements made in technical publications, but there are now so many engineers in the large cities of the United States who are convinced from their own records and personal experience that granite block pavements should not only be tolerated but laid extensively on their main arteries in their cities, that we feel compelled to reply to such an editorial as the one to which we have referred.

As we know the Engineering & Contracting magazine always opens its columns to a correction of any statement it makes which may seem to unintentionally harm a good material, we thank you in advance for your courtesy in giving this letter publicity in your columns.

Very truly yours,
ZENAS W. CARTER,
Field Secretary,
Granite Paving Block Manufacturers' Association of the U. S.
Oct. 25, 1916. Boston, Mass.

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## "WHAT IS A COLLEGE FOR?"

To the Editor: This is the title of an editorial in Engineering & Contracting of Sept. 20, 1916, reprinted from the Nov. 10, 1909, issue of the same publication. The writer would respectfully submit another question which may perhaps be considered in some degree related to the above. What is life for?

Will not the answer to the former depend in some measure on the attitude toward the latter? If the person asking himself the latter question answers that it is to enable him to make the most money possible in his life time, or that it is to afford him the opportunity to attain the most prominent and influential position possible to him, or that life is something he is to get the most possible out of, then his motive in life is entirely a selfish one and he should of course recognize that in discussing the former question.

If the purpose in life is to do the most we can toward making this world a comfortable and pleasant place to live in, for others as well as ourselves, then the college should be one of the chief agencies for promoting this end.

The engineering profession in general is engaged practically all the time (barring its military activities) on work that is in accord with this latter purpose. Then why should not engineers be ready to recognize this purpose as applicable individually as well as collectively?

The editorial referred to quotes from President Wilson, then of Princeton University, in part as follows: "The modern world needs more tools than managers, more workmen than master workmen. It (the college) is for the training of men who are to rise above the ranks." The editor sufficiently comments on and criticises the attitude of President Wilson (shown in other quotations) indicating that engineering schools were for training "workmen" and real colleges for training the "master workmen." The writer would venture the criticism of the attitude evident in the above quotations, an attitude not peculiar to the man quoted but all too common, as the writer thinks, in modern life in general. It is this, the evident habit of men at the head of affairs to look down on ordinary people as merely "workmen" or people in the "ranks," notwithstanding the fact that many of these same officials spent most of their lives in those same ranks and were no more respectable or respected than thousands who are now in the ranks.

The time was when it was not difficult to find a mechanic in almost any trade who was a real "master workman" even while doing the work, not bossing it. Those men were proud of their work and recognized its importance as a part or a general scheme. The selfishness of large employers forced workmen to combine into labor unions and fight for their rights thus rapidly developing their selfishness to such an extent that they often entirely ignore the rights of the neutral "general public," as do often their employers. One result of this has been to discourage the development of the kind of master workmen above referred to, since a very poor workman by joining the union and paying his dues regularly can receive the standard wages. Why need he (from the selfish viewpoint) strive to become an expert workman, unless it be to work for promotion out of the ranks, which rise will in a measure remove him from disgrace, in the eyes of his "superiors"? For the majority, who have sense enough to see that all of them can not become foremen, superintendents, managers or presidents, the selfish motive will either keep them from "overexerting" themselves to improve or else make them dissatisfied pessimists when they fail to get the desired promotion.

To return to the question of college education and especially engineering college education, why should we have as our principal aim the education and development of men for the high official positions when at the rate graduates are being turned out not over 10 or 20 per cent of them can possibly ever occupy such "exalted" positions? It is a fine thing for an institution to be able to point to numbers of its alumni who have attained high rank in the world of affairs and especially in their chosen profession. But should that same institution be ashamed to mention that much larger number of its alumni who are doing good respectable and important work in the world, but who are not and never will be widely known? Should they be treated even by the slightest implication as failures or as mere workmen but not master workmen?

If engineers are not considered first-class high-grade engineers until they have become chief engineers, consulting engineers or superintending or managing officials of some type, then the actual engineering work is being done by poor or inexperienced engineers, for we all know that the above mentioned officials do very little of the actual responsible detail work. If the engineers actually doing the work are competent then let us give them the credit due master workmen (and incidentally the salaries due such). Is it not then proper to try and teach or at least try and start engineering students on the road to become good efficient working engineers with the idea that if they are such they are eminently successful whether they are ever promoted to positions of great prominence or not? Will this not conduce toward making them contented and happy as well as useful citizens?

The writer would not detract at all from the honor of the official positions often carrying great responsibility and presenting difficult problems for solution, but he thinks the importance of the more subordinate positions is not sufficiently emphasized. It is all very well to say that it is easy to hire all the engineers or others required to do any piece of work, but that good leaders are hard to get. Nevertheless is it not generally true that when vacancies occur in official positions they are quite readily filled and that often the new incumbent proves more competent in some respects than the former one?

The writer thoroughly believes in not only an engineering education but an engineering experience as a prerequisite for a position of management or administration over any industry or organization that involves large amounts of engineering work. The engineer official is better able to appreciate the difficulties and fine points of the work of his subordinates in their detail engineering work and by fair treatment should receive better co-operation from them than non-engineering officials are apt to receive.

Much criticism is aimed at engineering education and its failures to properly educate engineers but little in the way of concrete suggestions of a practical workable nature is offered. Too many seem to look at the question from the viewpoint of the prominent engineer of 20 or 30 years' experience, apparently forgetting all about those years of experience and the many things learned there far better than they could have been learned in college, or else they feel a lack of something and blame the college when perhaps they might have supplied the want by broadening out a little during those years of acquiring practical experience. Nearly all young engineers must pass through years of practical work before reaching the official positions, if they ever do reach them, so it might seem reasonable to assume that the college's principal duty is to try and prepare them to enter properly upon those first years, with ideals that will stay by them and enable them to become and continue useful and contented citizens whether they reach exalted positions or never earn more than moderate salaries.

As to the subjects to be studied in an engineering course, the writer after 16 years of varied practical engineering experience and 9 years of teaching is of the opinion that few of the subjects commonly included in courses as now given should be cut out. Modern tendencies seem to be demanding more attention to such subjects as economics, accounting, efficiency, language, etc. But if very much time is given to these and other non-engineering subjects it means either cutting out some important engineering subjects or lengthening the college courses. It may be that very soon a majority of the larger universities will offer 5 and 6-year engineering courses as a few are now doing, but there will doubtless remain a demand for the 4-year courses also as many will not think they can afford the time and money necessary for the longer courses. It is a well recognized fact that a majority of engineers are unable to talk well in public and this probably more than any other one thing is responsible for the lack of engineers in public life. This could be remedied to some extent by requiring those taking 5 or 6-year courses to devote considerable time to public speaking, and debating, but there is scant room for effective work in that line in the ordinary 4-year engineering courses as now given. A young engineer graduated with fair ability in public speaking will, however, need to force himself to improve opportunities for continued practice if he wishes to retain the feeling of ease before audiences. Most lawyers, except office men, are compelled to talk, in practicing their profession, so they are usually more numerous in our national legislative bodies than the members of any other two callings, and are also very numerous in our state legislatures. The writer was recently informed that not a single member of the present congress was or ever had been a real engineer and that not over two or three ever worked with engineers to amount to anything. It is perfectly natural that lawyers, working from the selfish point of view, enact a multiplicity of laws of such a nature as to make more work for lawyers. It is equally true that if engineers had the chance they could improve on many of the laws enacted and would often do so even were they actuated only by selfish motives, for most of them have a pride in engineering work efficiently and well done and a considerable portion of the public funds is spent on engineering work.

Engineers to be of the greatest possible use to the communities in which they live and to the country at large, should keep in touch with the public questions of the day and not be so wrapt up in technical things that they are not even intelligent voters. If keeping in touch with the times results in their promotion professionally or their entrance into public life, well and good, but if not they are at any rate better citizens especially if actuated by unselfish motives.

These are some of the things students can be informed of, but when they graduate from a 4 or 5 or a 6-year engineering course they are not engineers and neither is their education completed. It is merely begun. If they do not read and think technically they will not develop in engineering as they might. If they do not read and think on civic matters they will be very indifferent citizens.

The editor advocates specializing in college to develop "breadth of brain by narrowing the field of study," also claiming that it holds the interest of the student. There is no doubt that the average student who completes a 4-year engineering course works harder than the average student who takes an ordinary liberal college course, if the latter has no definite aim other than athletics or just to be able to say he has been through college.

But the fact is that many of our very best and hardest working engineering students are recognizing that they need more of the broadening and "liberal" courses (not snap courses) than are required of them for graduation. The writer does not believe the 4-year engineering courses as generally now given are specializing too much; he does not believe in very high specialization until some practical experience has been gained, and thinks that more benefit will generally result in the long run if the extra subjects taken in a 5-year course are of the type before mentioned, non-engineering, than if the fifth year is put in as a post graduate year specializing along the same line as the undergraduate course taken.

No doubt many people honestly believe that a selfish motive, "looking out for No. 1," is the only motive that it is possible for an ordinary individual to live by and attain what is commonly known as success. It is of course necessary, under the present organization of society, for all who have others dependent on them to pay considerable attention to finances in order to "keep the wolf from the door." Society has not advanced very far beyond the jungle, however, if it is still necessary to cause the downfall of some in order that others may succeed. May it not be in accordance with the laws of social evolution that we, collectively and individually, are under obligation to help make our neighbors fit to survive along with us instead of merely striving to beat them in the race? It has been pretty well proven in commercial life that combination and co-operation tend toward efficiency, for the people who combine and co-operate.

The problem of keeping employed is a real problem for many people, for example, civil engineers and others engaged on large constructive work. When such work is completed many are thrown out of employment unless "times are good" and they have succeeded in shifting to other work as the force was reduced.

Some may say that if they have shown themselves competent they will have no trouble in securing other work, but such people are not very well acquainted with the actual conditions on public works and other large construction as carried on in relative dull times. How about the hosts of unskilled labor turned loose at such times? Another case somewhat similar but often more distressing is that of people who have been long employed in some industry and are turned out for efficiency's sake because of age or because some improvement in machinery or methods of operation makes fewer employes necessary.

Since unemployed people generally continue to live along with the rest of us many of them become burdens on others and often on society in general.

Then from the standpoint of social efficiency why should not society, or the government make it a business to see that all who are able to work are provided with work they are fitted to do? Some start is being made in the line of federal government employment agencies, but we are still far behind the times in this line.

The welfare and safety first work being done by many large corporations and others gives evidence that the spirit of altruism is on the increase.

What has all this to do with the subject under discussion? It seems to the writer that in general the attention that has been given in engineering education to technical and non-technical subjects has generally laid stress only on the selfish "look out for number one" point of view and that much more emphasis should be laid on the altruistic point of view.

H. P. Boardman,
Professor of Civil Engineering,
University of Nevada, Reno, Nev.

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Investigations conducted by the College of Forestry of the University of Washington show that a cord of full length wood when sawed into short lengths and repiled in the ordinary stack shrinks on an average 24.76 per cent. For close piling in which all the sticks are carefully fitted together the shrinkage is 13.28 per cent. It also was found that a wagon box is a more invariable standard of measurement. Short wood was thrown haphazardly into a box and leveled off with the tops of the sides. Several trials showed less per cent of variation than did either the loose or the tight piling methods.

## NEW TRAFFIC CODE OF COLUMBUS, O.

The council of Columbus, O., a city of some 200,000 population, has adopted a new traffic ordinance, containing a number of interesting requirements. The code becomes effective on Nov. 9. Its more important features are as follows:

In the congested district pedestrians must cross the street at right angles and at intersections only.

In boarding or alighting from a street car, pedestrians shall have the right of way to and from the sidewalk or car.

Pedestrians shall keep to the right on sidewalks.

Pedestrians shall enter and leave safety zones at crossings only.

Vehicles shall meet and pass each other to the right.

Police patrols, fire department vehicles, ambulances, gas emergency repair and street railway emergency repair vehicles, in responding to emergency calls, shall have the right of way.

Electric and other slow-moving vehicles shall keep as close as possible to the curb on the right.

Ambulances shall not be permitted to exceed the speed limit.

At all street intersections where no traffic officer is stationed, vehicles and street cars approaching the crossing on the right shall have the right of way.

Headlights shall be adjusted so that at a point 50 ft. or more in front of the vehicle, no part of the intensified rays shall be visible more than 3½ ft. above the surface of the street.

Spot lights, if used, must be directed only upon the road in front of the car, and at a distance not exceeding 30 ft. in front of the vehicle.

It shall be unlawful to operate a vehicle with the muffler or exhaust open or with any device or attachment to open or cut out such muffler.

No loaded truck shall be moved over the streets of the city between 10 p. m. and 6 a. m. to the annoyance or disturbance of citizens, unless special permit is obtained from safety director.

No vehicle shall stop on any street in the congested district except in such position that all parts of the vehicle shall be within 7 ft. of the curb.

All 5-ton and over motor trucks shall have their motors equipped with governors so that the truck cannot exceed a speed of eight miles an hour.

No heavily-loaded vehicle shall use the driveways in the parks of the city without permit.

No load in excess of 12 tons in weight, including weight of the vehicle, shall be driven over the streets.

It shall be unlawful to obstruct fire hydrants. Vehicles shall not stand within 10 ft. of either side of a fire hydrant or fire cistern.

No vehicle shall be left standing within 10 ft. of either side of the main entrance of any theater or public buildings during any meeting.

Any vehicle standing at the curb in the congested district—between Mound street and Buttles avenue and between Fourth and Front and Park streets—between the hours of 8 a. m. and 6 p. m. shall be moved away from the curb at the direction of a police officer or the request of the owner or agent of abutting property.

No vehicle shall stand at the curb on High St., between Mound St. and Buttles Ave., between 8 a. m. and 6 p. m. for a longer period than 30 minutes in any one square or in the same square within the following hour.

No motor vehicle shall be operated upon or over the streets of the city by any person under 16 years of age.

No person shall ride upon any vehicle without the consent of the driver.

Street cars shall stop on one side of intersecting streets at the lot line.

No person shall convey a child less than six years of age on any bicycle or motorcycle.

It shall be unlawful for any person to operate a vehicle of any kind on the streets of the city while in a state of intoxication.

Traffic officers may stop vehicles for the purpose of ascertaining the name of the owner or the driver, but is prohibited from using loud, profane, abusive or insulting language.

The general penalties provided for violation of the ordinance are a fine of not less than $5 nor more than $25, and for a second offense a fine of not less than $10 nor more than $50, or imprisonment in the workhouse not more than six months, or both.

## WHAT ARE THE ROAD-MAINTENANCE COSTS IN NEW YORK?

Contributed by Daniel T. Pierce, Philadelphia, Pa.

The actual costs of road maintenance on New York State's bituminous highways have never been clearly stated. We have had, it is true, some extravagant guesses on the part of a former governor of the state, and annually there is given out a summary that combines all asphaltic and bituminous roads and gives a lump-sum statement as to what they have cost. But as to particular roads and the way in which the money is spent on them is accounted for, no facts have up to this time been obtainable. For these reasons the figures presented herewith are of exceptional interest.

It appears that under the system followed in New York the cost of maintenance is distributed under the following headings: Improvements, Resurfacing, Engineering and Inspection, Ordinary Repairs to Road Surfaces (which is divided to show the cost of labor and material separately), Cleaning Macadam, Trimming Shoulders and Cleaning Tops, Oil (which is divided into the cost of the oil, sweeping, applying and covering and material for coverings), Guard Rail, Concrete, Tools and Plant, Patrol, Extraordinary Repairs and Miscellaneous.

In the figures herewith, showing the cost of maintenance per mile per year on 24 roads, the items charged to engineering and inspection have been eliminated in arriving at the figure showing the cost per mile per year. One reason for excluding the charges for engineering and inspection is that the latter items do not cover labor and materials actually required to keep the road surface in repair. A further reason is that there appears to be no relation between the cost of engineering and inspection and the amount of money laid out for repairs and materials. For example, road No. 646, built in 1910, has never been resurfaced, and yet we find that the charge against this road for engineering and inspection amounts to $620.35. In the case of road No. 686, where only $32 was spent for resurfacing, $631.39 was charged up for engineering and inspection. On the other hand, the records show a number of cases where large sums were spent for resurfacing and little or nothing for engineering and inspection.

Study of the New York maintenance sheets would indicate that the engineering and inspection charges were arbitrarily assessed against roads on which the labor and material outlay was negligible. Road No. 350 cost $3,651.92 for resurfacing in 1914. About $2,500 was also spent for oil used on the same road, and yet the engineering and inspection charge is $768, or about the same as is charged against roads on account of which little or nothing was spent for labor and materials; and in the case just referred to the larger part of the engineering and inspection charge—namely $596.17—appears under date of 1912, or two years before the large amounts were spent in resurfacing and for labor and materials.

Another example that may be cited is road No. 5047, which cost $2,106 for resurfacing in 1914, but carries an engineering and inspection charge of only $217.83 for the five years it has been under maintenance. Road No. 719 has never been resurfaced, is nearly three times as long as Road 5047 and shows a much lower cost of maintenance per mile, yet it carries an engineering and inspection charge of $1,072.40.

All of the roads on which maintenance costs are here presented were constructed by the penetration method. They were not selected with a view to proving anything for or against this method of construction or the materials used. As a matter of fact, there was no opportunity to select any particular roads, the only figures obtainable being those here presented.

COST OF MAINTENANCE PER MILE PER YEAR ON 24 NEW YORK ROADS.

1—Maintenance Cost, Less Engineering on 12 New York Roads Constructed with Residual Asphalt Binder.

| Number of road. | Miles. | Date accepted. | Total cost maintenance and repair. | Maintenance and repair, less engineering. | Cost per mile per year. |
|---|---|---|---|---|---|
| 5047 | 1.64 | 1911 | $ 5,732.99 | $ 5,515.16 | $671 |
| 630 | 2.24 | 1910 | 10,250.58 | 9,352.48 | 696 |
| 735 | 7.90 | 1910 | 12,908.94 | 11,444.49 | 289 |
| 769 | 4.21 | 1910 | 7,163.90 | 6,471.33 | 307 |
| 5076 | 5.22 | 1911 | 5,646.06 | 5,091.26 | 244 |
| 5086 | 5.04 | 1912 | 11,260.49 | 9,886.67 | 654 |
| 690 | 4.25 | 1910 | 8,583.80 | 7,274.87 | 285 |
| 669 | 5.98 | 1913 | 5,896.15 | 5,575.59 | 311 |
| 654 | 5.35 | 1910 | 8,074.40 | 7,319.59 | 228 |
| 393 | 3.61 | 1910 | 6,593.50 | 5,849.75 | 324 |
| 350 | 7.26 | 1911 | 16,335.48 | 15,567.31 | 420 |
| 796 | 2.54 | 1910 | 21,324.67 | 19,547.76 | 705 |

Average maintenance per mile per year...............$428

2—Maintenance Cost, Less Engineering, on 12 New York Roads Constructed with Fluxed Natural Asphalt Binder.

| Number of road. | Miles. | Date accepted. | Total cost maintenance and repair. | Maintenance and repair, less engineering. | Cost per mile per year. |
|---|---|---|---|---|---|
| 719 | 5.56 | 1911 | $ 6,369.37 | $ 5,296.97 | $190 |
| 5085 | 4.52 | 1913 | 5,068.79 | 3,971.34 | 293 |
| 5117 | 6.00 | 1912 | 6,328.65 | 5,999.26 | 250 |
| 415 | 3.37 | 1912 | 4,704.41 | 4,224.98 | 313 |
| 547 | 5.74 | 1912 | 6,689.44 | 5,717.34 | 248 |
| 571 | 2.61 | 1910 | 1,328.54 | 826.87 | 63 |
| 646 | 4.12 | 1910 | 3,724.80 | 3,104.45 | 124 |
| 650 | 5.66 | 1910 | 13,260.86 | 11,983.22 | 353 |
| 665 | 5.16 | 1912 | 4,656.48 | 4,145.07 | 201 |
| 686 | 8.72 | 1912 | 2,845.74 | 2,214.35 | 63 |
| 5054 | 2.00 | 1912 | 4,357.42 | 3,608.47 | 377 |
| 877 | .97 | 1913 | 1,076.54 | 978.37 | 336 |

Average maintenance per mile per year................$234

Eliminating engineering and inspection, guard rail and culvert charges; in other words, confining the figures strictly to those which relate to repair and maintenance of the road surface proper, the average cost per mile per year for the roads in the first classification above is $385, and for the second classification $213.

## MOTOR TRUCKS ON MASSACHUSETTS HIGHWAYS.

The 1915 traffic census of the Massachusetts Highway Commission shows the rapid increase in number of motor trucks using the highways in that state. According to the 1915 report of the Commission there were practically no motor trucks on the State highways in 1909. In 1912, however, there were 11½ a day on the average, and they constituted 3 per cent of the traffic.

In 1915 the average number of motor trucks was 38 a day, or 6 per cent of the traffic. They just about equaled the light-drawn vehicles, of which there were 39 a day in 1915. One must realize that this 38 a day is the average number at all the 192 stations when the census was taken.

The number of motor trucks on main roads near the cities was, of course, several times greater. There were over 50 a day on the average on the State highway in Pittsfield, Lenox, West Springfield, Deerfield, Hadley, Northampton and Leicester, while Longmeadow had 76 and Chicopee 95 a day.

On roads running out of Boston, 15 to 18 miles out, there were usually between 30 and 70 a day. Blackstone had 29, Uxbridge 30, Wayland 88, Grafton 44, Shrewsbury 46, Lexington 60, Tewksbury 41, Andover 70, Salisbury 63, Lynn 96, Stoneham 52, Salem 139. These roads fairly represent through, interurban motor truck traffic between Boston and cities like Salem, Lowell, Lawrence, Worcester, etc.

There are certain roads where much of the local traffic is by motor trucks carrying ice, coal, hay, express, etc.

In Gloucester there were 143 motor trucks a day, in Beverly 208, Salem 209, Saugus 151, Somerville 131 on the road to Medford and 102 on the road to Malden, Boston 120, and Watertown had 339.

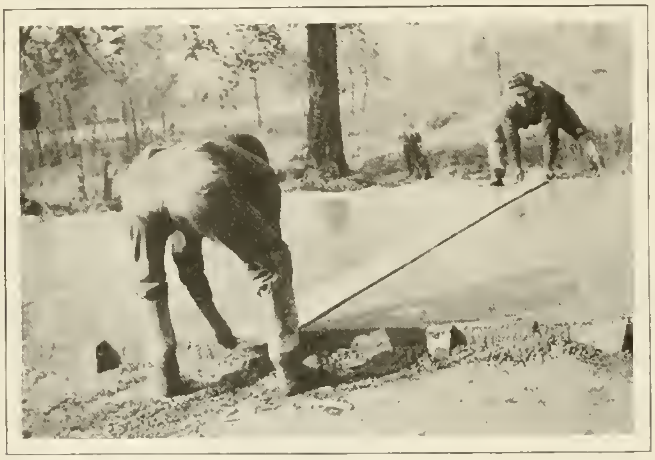
The same numbers of motor trucks are found south of Boston on the main roads. Quincy had 62, Dartmouth 130, Bridgewater 40, Middleborough 29, Marion 62, Falmouth 32, Seekonk 70, Harwich 48, and Hingham 132.

## CANVAS BELT FOR FINISHING CONCRETE ROAD REDUCES COST.

Contributed by D. A. Thomas.

A considerable saving in the cost of finishing a concrete road now being constructed under the supervision of the Michigan State Highway Department has resulted from the use of a strip of 12-in. canvas belting which is drawn back and forth across the pavement, thereby producing a surface which is in many respects superior to that obtained by the old methods of hand finishing.

In finishing the pavement, a strip of 3-ply, 12-in. canvas belting is laid transversely across the pavement, projecting a short distance beyond the forms at each end to enable the workers to hold it. After the surface has been struck off with the template, two laborers located on either side of the road drag the belt slowly back and forth, gradually working it forward. It is only necessary to use the belt a few minutes at intervals of 20 or 30 minutes to keep pace with the mixer. The men who work the template drop back and do this while the mixer is being moved forward. In this way three finishers have been done away with at a saving of nearly $1 per hour.



Method of Handling Canvas Belt.

The belt finishing levels all ridges, fills all hollows, eliminates the corrugated or wavy surface left by the template, and secures a most uniform finish throughout. The smaller pebbles are worked down and firmly imbedded in place in the concrete and a gritty surface produced without flushing excess water to the top or forming a film of neat cement on top. The uniformity is, however, the most noticeable result of the operation.

The road under construction is 18 ft. wide and is being built according to the standard specifications of the Michigan State Highway Department which eliminate joints except at such points where the work is stopped for more than 30 minutes. This is very favorable for the use of the belt for finishing as it eliminates the frequent use of the bridge at joints. It is of course necessary to use a split float at the joints and this can be accomplished satisfactorily only from a bridge.

By the omission of joints some slabs over 150 ft. in length have resulted. It is the belief of the department that if joints are omitted the cracks will form at approximately the same intervals at which joints are customarily placed and that such cracks can then be maintained in the same manner as joints. The early maintenance cost and the construction costs are thereby reduced to no small extent.

The belt method of finishing has but recently come into use. It has been extensively tried out in Wayne county, Michigan, and it was at the suggestion of the Wayne authorities that the department adopted it on the above mentioned road.

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The 14th Annual Convention of the American Road Builders' Association will be held in Mechanics Building, Boston, Mass., during the week beginning Feb. 5, 1917. In connection with the Convention, and in the same building, will be held the Eighth National Good Roads Show.

## THE SAND AND ASPHALTIC OIL ROADS OF MASSACHUSETTS.

The Massachusetts Highway Commission is generally credited with being the first to experiment in the construction of roads of sand mixed with some bituminous material. The experiences of the Commission with this type of highway are described in the recently issued annual report for 1915, from which the following notes have been taken:

In 1905, the Commission decided to build a road of sand and asphaltic oil on Cape Cod in Eastham.

The old sand road was graded, and about ¾ gal. of hot asphaltic oil per square yard was spread on it and covered with all the sand the oil would absorb. Another ¾ gal. of oil was spread on top of this layer, and this again was covered with sand, and on this layer ½ gal. of oil was spread and covered with sand. It was not possible with the crude methods them employed to spread the oil at all evenly; it ran into the ruts made by the carts and into the 16 hoof prints made by the four horses that hauled the old watering cart that contained the heated oil.

Consequently that year and the next the surface had to be broken up, cut into as small pieces as possible with a disk harrow, harrowed and mixed with a tooth harrow, and then shaped back and rolled. After that certain places needed more oil and had to be patched. A reasonably passable road was secured in about two years at a cost of under 25 ct. a square yard for the surface, or less than $2,250 a mile.

This road is still in existence. It has required more oil from time to time, ruts have had to be filled and bunches on the sides cut off by hand or with a road machine. It has, however, carried the traffic for these 10 years satisfactorily and is still on the job. The cost of maintenance on this road since 1905 has been on the average 2 ct. a square yard a year, or about $175 a mile a year.

Since that road was built, the Commission has constructed about 25 miles of roads made of sand and asphaltic oil by this layer method. The methods used in construction have been much improved.

The first and perhaps most important improvement is the hardening of the subgrade before any oil is spread. After the road is graded the subgrade is prepared of the required width (now 18 ft.; formerly 15 to 16 ft.) and this is hardened with clay or loam so that it is not much rutted by the wheels or pitted by the horses' hoofs when the cart containing the oil is hauled over it. The oil is immediately covered with the sand before any teams go over it and pick it up. This makes it possible to spread the oil evenly over the road surface before it is covered with sand.

The second improvement is the machinery used to spread the oil. There are now a number of especially equipped carts and trucks made with nozzles especially designed to spread the oil in a perfectly uniform surface over the road.

In all 25½ miles have been built by the Commission since 1905. The surface of these roads has cost from 21 to 23 ct. a square yard, the average cost being 26 ct. a square yard. For a road 18 ft. wide this would be $2,750 a mile, to which should be added the cost of grading, culverts, etc.

On the roads which have been in use at least 5 years, the average yearly cost of maintenance has been 1 ct. a square yard, or about $100 a mile a year.

The Eastham road has cost about twice as much for maintenance because of the crude methods used in its construction.

Besides these 25 miles of sand and oil road built by the Commission, there is on the Cape probably an equal mileage built by the towns themselves or under the "small town" act, under specifications obtained from the Commission.

In 1908 the Commission constructed the second section of sand and oil road that was built. This was constructed by the layer method. It took 2 years to get it into reasonably good condition.

It, therefore, seemed as if there might be some way of using the same or better materials and mixing them thoroughly, thereby securing a stronger and better road without too much increase in the cost.

In the fall of 1908, therefore, the Commission decided to try some experiments with various bituminous materials mixed with hot sand. Eleven sections of road were constructed and a different bitumen was used on each. Two qualities of tar were used and nine different oils or asphalt products.

In each case the subgrade was carefully prepared of the required width, and the mixture was spread as evenly as possible thereon and rolled with a light roller. The mixture was 4 in. thick in the middle and 3 in. thick on the sides. The sand and the bituminous materials were first heated, and then mixed by hand as thoroughly as possible, before being spread on the road.

Eight of these experimental sections practically failed within the year. Another section was never very satisfactory, and only two remained in good condition and are still in use, having been patched from time to time. The only sections that succeeded were the ones where a heavy oil with an asphalt base was used, or where this oil was used mixed with an equal quantity of A asphalt. This latter section was much better than the other two.

These experiments showed clearly that it was possible to build a satisfactory road with sand mixed with oil asphalt if the proper asphalt product was secured and used. From 18 to 20 gal. of bitumen were used to the cubic yard of sand. The cost varied from 17 to 31 ct. a square yard.

The success of the asphaltic oil sections encouraged the Commission to go on with the work, and in 1909 over a mile of road was built by the mixing method. This road proved a success, although the oil used was rather light and consequently there was a little tendency to rut. Also, this road was surfaced only 15 ft. in width, with the result that vehicles in passing each other often turned out into the soft sand shoulder and sheered off the sides of the hardened road surface. It was rapidly cut into and narrowed up, especially on the curves.

The second year it was all widened to 18 ft., with a greater width on the curves, and all the roads of this character that the Commission is now building are 18 ft. in width, with 21 ft. on the curves. The Commission is widening the older roads as fast as it can.

The Commission is now using an asphaltic product that contains more asphalt than was used at first. Various asphalts have been used, both residium and natural, and on this mixed work an oil asphalt is now used that tests 80 penetration on a Dow penetrometer.

New mixing machines have been made, and their use insures a much more even mixture of the sand and oil. Until 1915 the sand has been heated on sheets of iron with a fire underneath, or over the old boiler plates or pipes. The sand had to be constantly turned by hand, but even then occasionally some of it was too hot and got burnt, and some was not hot enough. Now several sand heaters have been designed and have been used with good results. In these the sand is kept in motion all the time it is being heated, insuring a uniform heating of the sand.

It has been found advisable to spread a sealing coat of asphaltic oil of a little lighter quality over the road after it has been rolled, covering this with sand. The engineers are careful to secure as good a quality of sand as possible, and sand of a good quality can usually be obtained on Cape Cod. This means a sharp, strong sand that is pretty well graded in the bank. These sands have been tested and found to correspond very closely with the sands used under the ordinary sheet asphalt specifications.

The quantity of oil asphalt that is used has to be varied a little according to the variations in the quantity of voids in the sand. Eighteen to 21 gal. are used to the cubic yard of sand.

The roads are built over a carefully prepared and hardened base, about 4 in. thick in the middle and 3 in. on the sides, 18 ft. in width, with 21 ft. on the curves.

Better results have been secured by using a road scraper and keeping the mixture constantly shaped while it is being rolled. As stated above, a seal coat of a lighter oil improves the road surface and prevents it from having occasional potholes, and decreases the cost of future maintenance.

The Commission has constructed over 23 miles of mixed sand and oil asphalt roads since the experiments made in 1908. It has also built over 1½ miles of sand mixed with tar.

The cost of these sand and oil asphalt roads has varied from 40 to 61 ct. a square yard, the average cost being 52 ct.

The average cost of maintenance per year on these mixed roads that have been in use 5 years has been 1 6/10 ct. per square yard per year; on roads that have been in use 3 years the yearly cost of maintenance has been ¾ of a cent a square yard. If these roads require a seal coat every 4 or 5 years, as seems probable, the average yearly cost of maintenance will be about 2½ ct. a square yard a year.

Some sections of sand and oil roads have failed, and one section of sand and tar was not successful. These were roads built several years ago, and the failure was undoubtedly due to the poor quality of the oil asphalt or tar that was furnished and used, because these comparatively short sections have been rebuilt or repaired with a better quality of oil asphalt and have proved satisfactory.

While all the materials used were tested in a laboratory, there was very little knowledge a few years ago as to what qualities were necessary either in asphaltic oils or in tars to make a good road. Now that the Mexican and other asphaltic oil fields have come into use, it is much easier to secure good oil asphalts and good results than it was formerly. The manufacturers of both the tars and the asphalts have also learned what is needed and have greatly improved their processes of manufacture, and also have used greater care to secure uniform product.

Sand and oil asphalt roads can be used only when a sand of the right quality is available, and under present methods can be used only where the traffic is mostly light teams and automobiles; they will not stand up if they are used by many heavily loaded teams every day.

The layer roads are more easily rutted by teams than are the mixed roads, for two reasons: first, one cannot use as heavy a quality of asphaltic oil because it cannot be made to mix with the cold sand; second, because by the layer method one can never secure as even a mixture of the sand and oil on every part of the road.

The traffic that has been carried successfully as shown by the traffic census taken in 1909, 1912 and 1915 is about as follows, the figures being the average daily traffic:

Eastham, 1905 road, layer method: 20 heavy teams, 17 light teams and 253 automobiles.

Sandwich, mixed method: 8 heavy teams, 23 light teams and 502 automobiles a day.

Plymouth, mixed method: 3 heavy teams, 8 light teams, 257 automobiles. (This last count was made on a through road a long distance from any settlement. The other counts were near small villages and carried local traffic.)

There has been some fear that heavy motor trucks may injure these roads, though the road in Plymouth carried 8 and the road in Sandwich 9 motor trucks a day on the average with no appreciable damage to the road.

If the traffic in the future proves to be too heavy for the roads built by the methods above described, the Commission has no doubt that they can be greatly improved and strengthened at a moderate increase in cost by using better and harder asphalts and greater care in selecting and grading the sand, also in heating and mixing. The sands can be carefully graded, a portable sheet asphalt plant can be used, thus insuring uniform heating and mixing, and the best quality of asphalt can be used. By this method a standard sheet asphalt pavement can be made and laid 2 in. in thickness, using the old sand and asphaltic oil roads as a base. The same material can be used to resurface the old water-bound macadam roads in those sections of the State where sand of the right quality is available.

The Commission has very little doubt that such roads will satisfactorily carry any traffic that will go over them for many years to come.

Up to the present time where the sand and oil asphalt roads are being built, there is not enough heavy traffic to warrant the additional expense. The Commission expects, however, to use this better material in resurfacing some of its older roads on the Cape where there is heavy team traffic.

So many engineers and county commissioners from other States have come to Massachusetts to see these sand and oil roads, and so many letters of inquiry have been received asking for specifications and directions for building these roads, that the Commission feels that it should as emphatically as possible state a few facts.

A good road cannot be built by the use of any old oil, even if the agent selling it states that it is full of asphalt. An oil asphalt of good quality that will bind and not lubricate must be used. The quality of the oil and the asphalt in it can be determined by using the standard tests. Then make sure that all the oil asphalt used comes up to the standard.

It is not every sand that can be used. Many sands are too fine, too uniform in size, too rounded, and not strong enough. The sand used by the Commission is hard, strong and sharp, and is found well graded in the banks. The only way to insure success is to use the proper materials and proper methods.

Before any contract is let or any large amount of work is undertaken, it would be wise to build some experimental stretches of road, using the materials expected to be used in practice. In warmer climates it will undoubtedly be wise to use harder oil asphalts than have been used in Massachusetts.

When the traffic is heavy it will undoubtedly be economical to grade sands, possibly add some stone, use a percentage of cement to make a denser mixture if the sand is not of good quality, use a portable asphalt mixer, and construct a sheet asphalt road or a Topeka mix. Build roads so wide that they are not rapidly destroyed by teams having to turn off the road and so shearing off large slices on the sides.

There is no class of road built that will go to pieces any quicker than roads of the above character, if they are not constantly maintained. A pothole in wet weather will soon become as big as a bushel basket, and with many holes of this kind the road is not only very quickly destroyed by the traffic, but it becomes impassable. Thousands of dollars are lost every year because this maintenance is neglected, the holes not being filled.

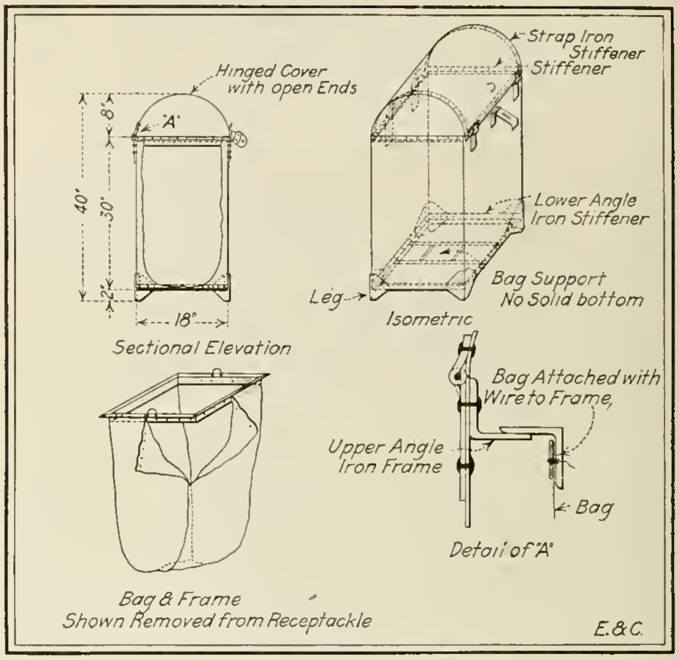
This does not mean a great expense; the costs are given above. Even when the greatest care is used in constructing the road, a few holes may develop, perhaps only three or four to the mile the first year or two; inspect the road, fill the holes, spend a few cents and save hundreds of dollars.

## 28-YEAR-OLD ASPHALT-COBBLE STONE PAVEMENT.

About 28 years ago the city of Columbus, O., resurfaced three of its old cobble-stone pavements with asphalt. In a paper presented at the recent American Society of Municipal Improvement convention Mr. T. H. Brennan, superintendent asphalt construction, stated that these pavements are still being mainained. Two of them should have been resurfaced not later than the twentieth year, but the third (Dryden Road, Parsons Ave. to 22d St.) is still in fair condition, and with a reasonable amount of maintenance it can be kept in repair for several more years. Another old cobble-stone pavement resurfaced 15 years ago (Washington Ave., Broad St. to Town St.) is in excellent condition. It has not had any repair and shows no signs of cracking or disintegration.

## STREET REFUSE CAN.

A special design of street refuse can proposed for use in the business section of Dallas, Tex., is shown in the accompanying sketch. This receptacle is to be used particularly for the waste paper, banana peels, etc., so often thrown onto the sidewalk or into the street gutters by pedestrians. In a paper presented before the American Society for Municipal Improvements Mr. Charles Saville, director of public health, of Dallas, states that in lots of 25 or more this can may be furnished at a cost of about $7.50 each.


Hinged Cover with open Ends
'A'
8"
40"
30"
2"
18"
Sectional Elevation
Strap Iron Stiffener
Stiffener
Lower Angle Iron Stiffener
Bag Support No Solid bottom
Leg
Isometric
Bag Attached with Wire to Frame,
Upper Angle Iron Frame
Bag
Detail of 'A'
Bag & Frame Shown Removed from Receptackle
E.&C.

Details of Street Refuse Can.

## STANDARD TESTS FOR BITUMINOUS MATERIALS.

At the recent convention of the American Society of Municipal Improvements the Committee on Standard Tests for Bituminous Materials, submitted the following conclusions for the consideration of the members of the society:

It is the judgment of the committee, based on present knowledge, that the inclusion of the paraffine determination in paving specifications serve no useful purpose.

The committee believes that specifications for bituminous cements for paving purposes should cover the following properties:

(1) Proper consistency; determined by penetration, melting point, float or viscosity test, or other test to be devised.

(2) Proper binding quality (no agreement has been reached by the committee as to tests which fully determine this property).

(3) Stability, including retention of physical and chemical properties:

For asphalts, determined by loss on heating and consistency of residue, or other tests to be devised.

For tars, determined by distillation test and consistency of residue, or other tests to be devised.

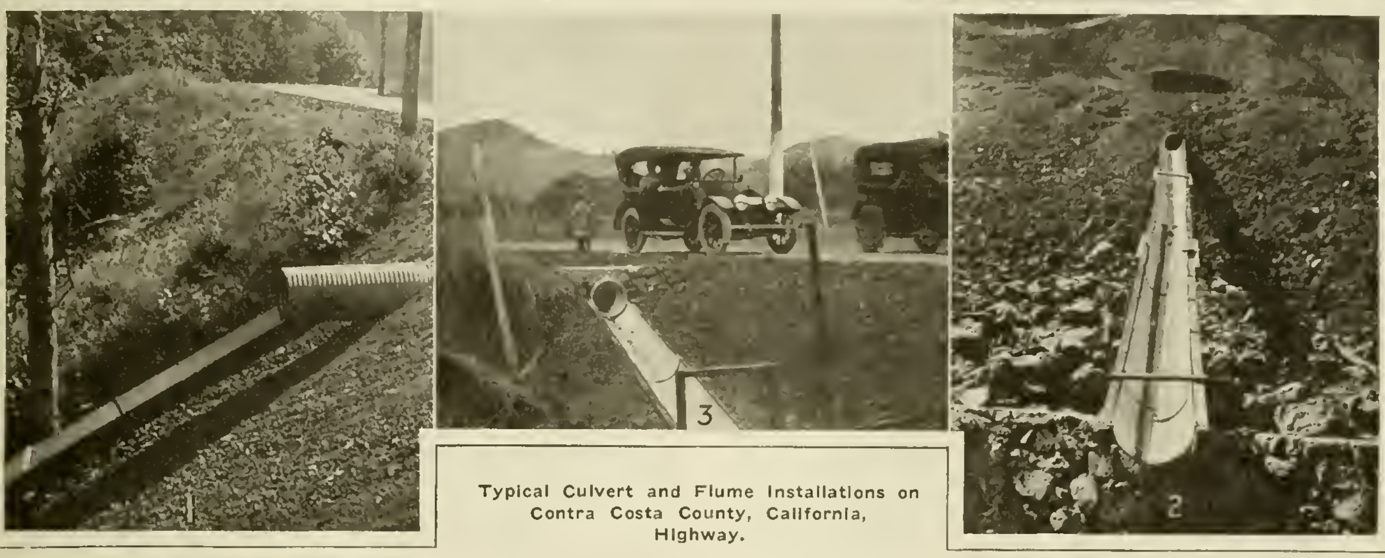
The committee believes that when the bituminous cement is combined with the mineral aggregate, the mixture should possess (a) toughness; (b) resistance to abrasion; (c) malleability; (d) stability; and that tests should be devised covering the measure of each property.

It is recognized that the tests enumerated do not fully cover the properties mentioned above. The committee hopes to elaborate existing tests and devise new ones and invites the co-operation of the members of the society to that end.

The committee consists of the following: Arthur H. Blanchard, chairman, New York; Prevost Hubbard, Washington, D. C.; Lester Kirschbraun, Chicago, Ill.; Felix Kleeberg, New York; Francis P. Smith, New York.

## METHOD OF PROTECTING HIGHWAY EMBANKMENTS.

In highway work in hilly regions it often happens that a culvert is installed in such a way that its outlet end is upon a high bank or fill. When no provision is made to guard against the erosion of the embankment underneath the outlet, serious washing is sure to ensue and this may proceed to such an extent as to practically destroy the installation. This is notably the case with any form of pipe made up of a series of sections not securely enough joined together to enable the pipe to maintain itself with some of its joints unsupported.



Typical Culvert and Flume Installations on Contra Costa County, California, Highway.

Corrugated pipe is sometimes a complete remedy for these conditions, the very simple method being adopted of having it extend several feet beyond the point where it emerges from the bank, thus depositing the water at a point where it will do little if any damage.

In some places, however, the bank is so high or slopes so gradually that this device cannot be effectively employed. The accompanying illustrations show the methods by which County Surveyor Arnold of Contra Costa county, California, has cared for such situations on the new concrete highway recently completed under his charge from Berkeley to Walnut Creek. Large numbers of Armco iron culverts were employed and wherever one protruded on a fill in such a way that its discharge might ultimately damage the embankment, a section of semicircular flume of the same metal was attached to convey the water to the desired point.

Figure 1 shows a typical installation of this sort. The flume is connected to the culvert with an iron loop or ring tightly cinched. Its edges are sustained and protected by 2-in. by 6-in. timbers. Angle iron side rails might be employed in the same way and perhaps would result in a better appearance in the long run.

Figure 2 shows the flume so placed as to carry the water over a stone wall at the bottom of the bank. Figure 3 illustrates a slightly different condition. Here the water runs along the road side until it is directed into a 2-ft. length of corrugated pipe installed in a concrete wall from which it flows through the flume section on a decided slope to the bed of a nearby water course.

## GRAVEL ROAD MAINTENANCE IN DALLAS COUNTY, TEXAS.

Dallas County, Texas, has about 480 miles of gravel roads. These roads carry a large amount of automobile traffic, as is shown by the fact that in the city of Dallas, with a population of about 125,000 there are 15,000 automobiles. There is an abundance of road gravel in the county, but this is confined to a strip 5 by 10 miles, making it necessary to ship the material to other parts of the county. This brings the cost of the gravel to about $1.50 per cubic yard in place.

In North Texas, the summers are usually fairly long and dry, and as a result the bond in the gravel road surface becomes destroyed, making the material easily displaced and the finer part blow away. It is out of the question to try and use water on these roads on account of expense, and an asphaltic top or heavy asphaltic oil top has not been very satisfactory on these gravel road surfaces.

The method employed by Mr. J. F. Witt, County Engineer, in maintaining these gravel roads is as follows:

The crown line is kept true by using road graders at the proper time; that is, after rains, and as pot holes appear they are filled up with gravel. This procedure is followed with constant care for, say, seven years; the cost being about $100 per mile per year. At the end of the seven-year period or in the eighth year, the road surface should be smooth and probably will look as though the surfacing is good for many more years. It is found, however, that the loss of gravel under traffic and by being blown away is so much and the surfacing plate so thin that if a long, cold and rainy winter should catch the road in this condition, spring would find the surface practically destroyed. In the 8th year, therefore, the entire surface is gone over with about 40 per cent of the amount of gravel placed in the original construction. This brings the total upkeep cost for the entire 8-year period to $240 per mile per year or 8 per cent of the original cost. This maintenance cost has proved ample for the main country roads, except a few miles on the city end of each road where the traffic is so heavy as to run the cost above the figures given. The county is trying to get away from this condition by putting down hard surfaced roads where the traffic is heavy.

Gravel Road in Dallas County, Texas.

## COUNTRY ROAD AND HOUSE NUMBERING SYSTEM.

The Iowa Highway Commission has developed a system for numbering country roads and houses in the state so that the location of every road and every farm residence will be instantly recognizable upon hearing the destination. The arrangement is described in the September Service Bulletin of the commission, from which the following extracts have been taken.

Under the proposed system the state capitol building at Des Moines is taken as the base or central point of the system.

The capitol is located on what was, before being cut up into city blocks, section 3, township 78 north, range 24 west of the fifth prime meridian. Using this as the central point, the sketch, Fig. 1, will illustrate the system of numbering east, west, north and south. The road touching the east side of this section would be East No. 1; the second East No. 2, and so on to the extreme east border of the state, the highest number probably being 176 in the extreme point of Clinton county above Lyons, Iowa. The road touching the north side of the section would be North No. 1; the second North No. 2, and so on to the north border of the state, which would be No. 132. The road touching the west side of the section would be West No. 1, and so on to No. 154 in the extreme western part of the state. The road touching on the south would be South No. 1, the second South No. 2, and so continue to the extreme southern border, which would be No. 70.

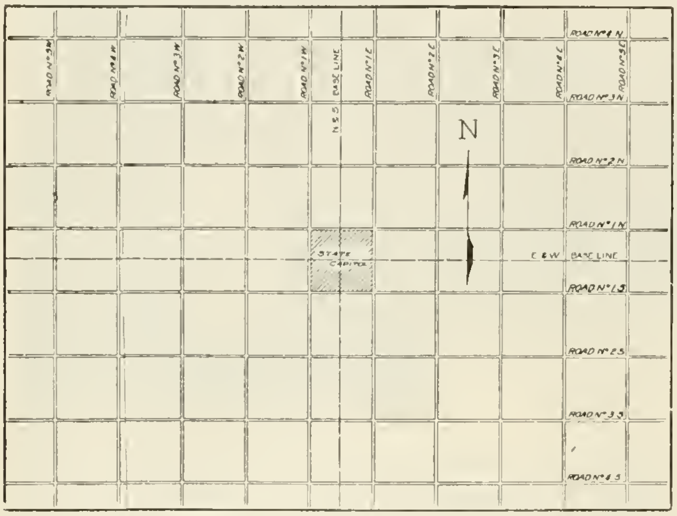


Fig. 1—Key to Road Numbering System.

All roads would be numbered with reference to the surveyor's section line. A road located off the section line any appreciable distance would be designated by a fractional number added to the number which designates the section line. For instance a road approximately on a quarter-section line would be No. 24¼, if located, say, between lines 24 and 25; if on the half-section line or near it it would be No. 24½. Such fractional numbers could accommodate all irregularly laid out and angling roads.

In carrying out the system it would be necessary to add in the south two-thirds of the state six fractional numbers to indicate regular section line roads in order that all north-and-south roads may carry the same designation entirely across the state. This is made necessary by the convergence of the meridian lines as they run toward the north.

On only the north and central lines would it be necessary to add additional numbers in order that all north-and-south roads may carry the same designation from the south to the north border of the state. Without these fractional numbers it would become necessary at some of the jogs along the correction lines to change the designation of a road.

The system of house numbering is indicated by Fig. 2. For simplicity each farm residence may be considered as located on a quarter section. Each mile of road has facing it eight quarter sections—four on each side of the road. By considering each quarter section as having a number as 1, 3, 5, 7, on the east side and 2 ,4, 6, 8, on the west side, any farm may readily be located by affixing to the last cross road number the number indicating the quarter section in which the house is located. Use the odd numbers for the east side of north-and-south roads, and the north side of east-and-west roads, and the even numbers for the west side of north-and-south roads and the south side of east-and-west roads.

As a typical section to illustrate the system use a section between roads North 23 and 24 and East 118 and 119, and refer to the chart for numbering farm houses (Fig. 2). A house in the southeast corner or quarter section is shown facing road East 118. This house is north of road North 23. It is in quarter section No. 1; hence its number would be 23-1, or simplified 231. The house on the same side of the road in the quarter section block immediately north of quarter section No. 3 would be 23-3, or 233. All these houses face on East 118, and they are all north of the base line east and west through the state capitol from which all numbers are designated. Hence these house numbers should all be designated as north, or 231 North and 234 North. The complete designation would be 231 North on East 118; dropping the preposition 233 North, East 118; 234 North, East 118. Were this section between roads South 23 and 24 instead of between North 23 and 24 the house numbers would be 231 South, East 118; 233 South, East 118, and 234 South, East 118.

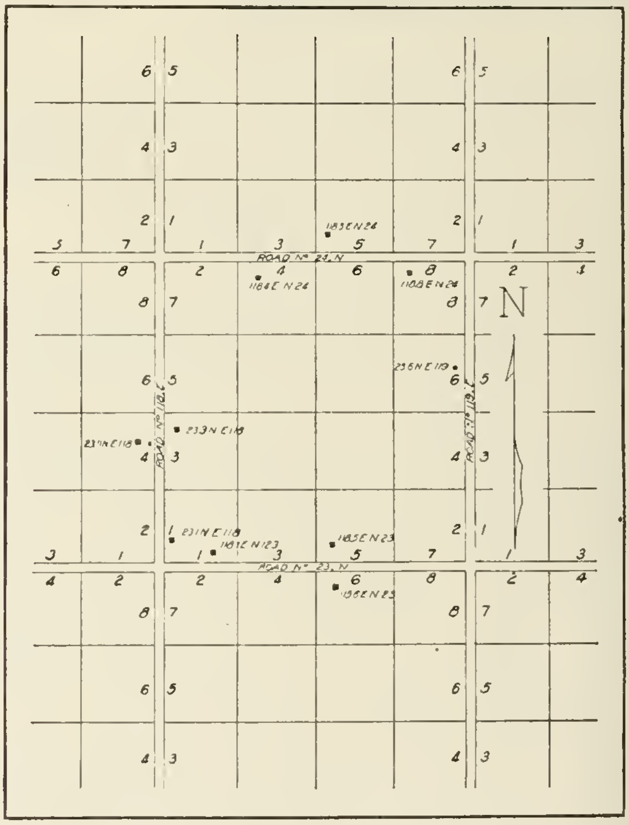


Fig. 2—Numbering System for Farm Houses.

The house facing south on North 23 and in quarter section No. 1 adjoins road East 118. Its number would be 118-1, or 1181, and being east of the north-and-south base line through the capitol would be designated as east; hence its number would be 1181 East, on North 23, or 1181 East, North 23.

Where two or more houses are located in the same quarter section fractional numbers make the designation easy and clear, as 231½ or 233½ North, East 118. Where fractional numbered roads are designated the fraction should be treated as an integral number and all confusion avoided, as on West 15½. A house adjoining this fractional numbered road would be 15½1, 15½2, etc. The same system of quarter section numbering accommodates all houses located on irregular or angling roads.

## WHAT CAN BEST BE DONE TO ADVANCE THE INTERESTS OF THE ENGINEERING PROFESSION IN THE UNITED STATES?

A 44-page paper bearing the above title was read by Dr. J. A. L. Waddell before The Engineers' Society of Western Pennsylvania, and published in the July proceedings of the society. We have space to give only the following bare outline of this interesting paper. To quote:

Do not the preceding facts constitute sufficient evidence that there is a necessity for American engineers to make a concerted effort to advance the interests of their profession and to change materially those existing conditions which cause the unsatisfactory state of affairs. There can be no doubt whatsoever about the expedience of such concerted action; hence it will be well to summarize the undesirable conditons and the alleged deficiencies in the general make-up of American engineers. Those most commonly recognized or claimed are the following:

A. The importance of the engineering profession is not at all adequately recognized by the general public.

B. Engineers as a class are not paid enough for their services.

C. Engineers are not sufficiently often appointed to high executive positions for which their special training and knowledge eminently fit them.

D. In most joint work where a lawyer and an engineer are employed, the lawyer is usually given the leading part and the greater compensation, and the engineer is forced to fill a subordinate position with small pay.

E. Engineers do not take a proper interest in politics; and hence are not given any of the political plums, these going generally to the lawyers and the business men.

F. Engineers are too modest for their own good, hence their great works are comparatively unknown outside of the technical world—and often none too well within it.

G. Engineers as a class are lacking in the ability to speak readily and convincingly in public, and hence cannot influence the masses or guide their efforts towards the accomplishment of important desiderata.

the accomplishment of important desiderata.

H. Engineers are trained too closely along narrow mathematical and technical lines and not in those which develop them broadly as men and as citizens.

I. Engineers, as a class, do not pay sufficient attention to the proprieties, do not dress with sufficient care, do not have sufficient dignity, and rather look down upon a man who concerns himself seriously with such matters of minor importance as personal appearance and the general requirements and trifling obligations of society.

J. American engineers, as a rule, have not a thorough command of their native language in either writing or speaking, owing mainly to the fact that they have been taught to look upon language-study as of far less importance than mathematics or technics.

K. American engineers, because of their narrow training, are not interesting members of society, in that they are unable to converse well upon general subjects, and because they are not keen in regard to any matter that lies without the pale of their professional life.

L. There is a lack of ambition and earnestness among the rank and file of the engineering profession, making them content with earning their comparatively small monthly wage and with living a hum-drum life, and preventing them from advancing beyond mediocrity.

M. There is as yet no adequate general code of ethics established for engineers, and for that reason the profession cannot stand as high in public estimation as the other professions which have such established codes.

N. There is a lack of harmony among engineers as a body (due possibly to the need of a proper code of ethics, but probably also to a number of other important reasons), which tends to hold back the progress of the profession.

O. The field of activity of the American engineer is too restricted—both from a business standpoint and geographically.

As before stated, these are the common allegations made against engineers and their vocation by both its members and the laity; but please understand clearly that they are not those of the speaker, for while he cannot deny the existence of numerous shortcomings in the engineering profession, he maintains resolutely that it is the grandest and most worthy profession of them all, in that to it are due the wonderful progress of mankind which has characterized modern times, and all the comforts and conveniences of life that make it truly worth living instead of the heavy burden which it was often claimed to be by our ancestors of a few generations ago.

The correction of these and other faults in the American system of early education is a national matter of great importance, and not one to be undertaken by any single profession, unless it be that of pedagogy.

The improvements necessary for engineering courses in general in order to increase the efficiency of the students as much as practicable, arranged in the order of their importance, in the speaker's opinion, are as follows:

1. Extending the duration of the course from four to at least five, and, preferably, six years; or else the establishment of separate schools for post-graduate engineering work of all kinds.

2. Arousing the enthusiasm of the entering freshmen in respect to the profession of engineer, showing them its grandeur and its usefulness to mankind.

3. Inculcation of a love of study and work for their own sake and not mainly because of the money that can be earned thereby.

4. Instruction as to how best to study so as to save time and labor, or, in other words, the economics of mental effort.

5. A thorough, elaborate, and systematic study of sound business-English, extended over each year of the entire duration of the course.

6. A general broadening of the course of study so as to include thorough instruction in such important lines as economics, history, oratory and business.

7. Making the study of the Spanish language obligatory and that of any other foreign modern language optional.

8. Improving fundamentally the study of all foreign languages, so that upon graduation all the students thereof shall be able to read, write and speak them fluently, correctly and gracefully.

9. Study of the art of systemization and its application to all lines of activity.

10. Teaching of ethics for engineers.

11. Accumulation of individual libraries, and showing how to utilize them properly.

12. Establishment of better opportunities for acquiring individual scholastic distinction by the students.

We shall now pass to the consideration of what can best be done by young engineers in order to advance the interests of the profession. The possibilities may be listed as follows:

1. Continuing study after graduation.
2. Buying books and collecting data.
3. Post-graduate work at some leading technical school and obtaining of advanced degrees.
4. Joining technical societies.
5. Systemization of work.
6. Adherence to professional ethics.
7. Setting an ultimate goal to attain.
8. Writing technical papers and books.
9. Publicity of achievement.
10. Helpfulness to others.
11. Becoming a useful citizen, attaining prominence in the community, and keeping abreast of the times.
12. Studying the science of business and salesmanship.

In respect to continuing study after graduation it may be stated, without any reservation whatsoever, that the man who fails to do so is the man who will not meet with any marked professional success—in fact, he is not even likely to attain mediocrity. One can seldom do any piece of engineering work in the best possible manner without first learning how similar work has been done in the past, and to ascertain this he must read and study. One should not only peruse the leading American engineering papers, the proceedings of one or more technical societies, and the principal new books in his chosen specialty, but also he should study such subjects as economics, engineering law, commerce and trade, and the general progress of science. If he has not already done so at school, he would do well to study the Spanish language, and in case that he has already a command of it, he should read enough Spanish books and papers to prevent himself from becoming rusty, besides practicing the speaking of it on every possible occasion. It is an excellent plan for the young engineer to keep up his mathematics by reviewing what he learned of the subject in his college course, but it will not be worth his while to continue it any farther unless his work so require, because the mathematics given in any good technical curriculum are generally sufficient for the needs of the practitioner.

We shall now pass to the last division of the subject of this address, viz., what can best be done by the old, established engineers to benefit the profession, and, as in the two preceding cases, we shall list the possibilities as follows, recording them this time, as nearly as may be, in the order of their importance:

1. The establishment of an American Academy of Engineers.
2. Distinctions and rewards for effective and important services.
3. Acting as advisors to the American Government.
4. Aiding to pass proposed legislation that is favorable to the engineering profession and to prevent all that is unfavorable thereto.
5. Establishment of a clearing house for the employment of young engineers as well as of older ones of minor grade.
6. Improving engineering education.
7. Improving engineering literature.
8. Bringing engineers into closer touch with capitalists.
9. Securing for American engineers important appointments in foreign countries.
10. Placing road-building under the control of engineers.
11. Placing city planning in the hands of engineers.
12. Placing municipal management under the jurisdiction of engineers.

## COLOR SCHEME OF DESIGNATING HIGHWAY ROUTES.

The Massachusetts Highway Commission has adopted a plan of designating routes by bands of colors placed on posts, poles, etc. It was decided to adopt a band of red to mark all main routes running east and west, a band of blue to indicate all main routes running north and south, and a band of yellow to indicate all secondary or diagonal routes. Where two routes crossed each other, bands of both colors were to be used on each post at the junction. If three routes intersected, all three colors were used.

Where two routes follow the same road for a distance, bands of both colors are put on the posts. The engineers were directed to have a band about 6 in. in width painted on two or three posts or poles on each side of each street corner or intersection. If the route turns a corner, the bands show on the posts beyond the turning, and there are no bands beyond on the road that the route diverts from. In a few places for short distances three routes will follow one road.

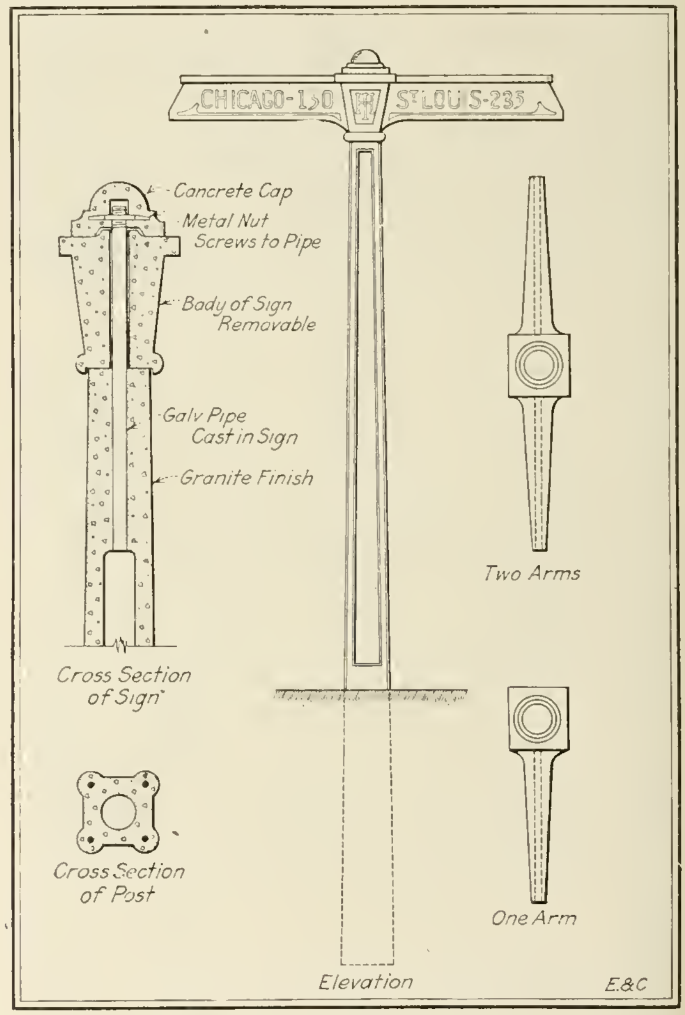
Where the Massachusetts main routes connect with main routes in New Hampshire and Vermont, the engineers were directed to have bands painted below the bands that were painted on the posts in those States, and that Massachusetts colors should be painted on a number of posts beyond the line. At the same time the Commission painted a number of posts in Massachusetts with bands of the same colors that had been used over the line in New Hampshire and Vermont. This clearly indicates to the tourist that the routes are identical and what color he should follow to continue on the route.

In a number of the larger towns and cities, it was possible to mark a route that would keep the tourist away from the congested streets and the center, and also secure him a better road, less delay, and, more important, would greatly lessen the possibility of accidents.

Red bands were used to indicate the main routes east and west. On a number of posts a narrow margin of white was painted above and below the color. This made the color much more conspicuous.

## NEW ROAD SIGN FOR USE ON ILLINOIS STATE AID ROADS.

Some time ago the Illinois State Highway Commission announced that a prize would be given for the best design submitted for a road sign to be used on State Aid roads. The design awarded the prize is shown in the accompanying illustration. The design was made by Mr. Walter H. Liensch, Chief Engineer Universal Concrete Products Co., Chicago, Ill.



New Sign for State Aid Roads in Illinois.

## COLLECTING LOOSE PAPER IN BUSINESS DISTRICT OF SAVANNAH, GA.

Savannah, Ga., has a money making method of collecting loose paper in the business district. The city, without cost to the merchants and others, places wooden boxes of from 1 to 2 yd. capacity at various localities in the lanes, of which there is a regular system throughout perhaps 90 per cent of its area. At this time there has been placed approximately 150 of these boxes, and the result of this has been a marked improvement as regards the cleanliness of the city. These boxes are emptied daily, and at present the paper collected from the boxes is sold unbaled for $3.50 per ton.

## THE SELECTION, TRAINING AND CARE OF THE HORSE FOR STREET CLEANING WORK.*

### Selection of New Stock.

In selecting and judging one must have a fixed standard concerning the conformation and type. A good judge can work with great rapidity and within a short time note the important defects present, and, knowing the nature of the work, render an immediate opinion as to the animal's fitness or adaptability. The time for buying may be any time during the year except midsummer, but preferably in the first six months.

The characters to be considered in the standardization are age, weight, height, form, quality, substance, condition, temperament and color.

Age, 5 years; weight, 1,550 lb.; height, 16.2 hands. These three characters are approximate, the last two combined are synonymous with size.

Form.—This is the general contour of outline which determines whether the horse is smoothly turned, angular, massive, low set, or rangy.

Quality.—This refers to the character, texture and finish of bone, hide, hair, sinews, and general refinement.

Substance.—This refers to the structural material and size of individual units of structure.

Condition.—This refers to the health, flesh, fat and leanness of the animal.

Temperament and Manners.—Refers to disposition and intelligence.

Color.—This refers to hard or soft; the soft being usually the mealy bay, the washed-out sorrel or the pinked-skin grey.

The standard draft horse should show a head of good size in proportion; clear-cut features, straight face and good jaws; a broad muzzle; large nostrils; thin lips; eyes prominent, full and bright; broad, full forehead; fine, well set, medium sized ears; neck long, muscular and well crested; good throttle, with head well set.

Forehand.—The shoulders must be long, sloping, smooth and muscular; arms, short and muscular with elbows in; forearm, wide and muscular; knees, straight, wide, deep and strongly supported; canons, short, broad, flat with tendons sharply defined and set well back; the fetlocks wide, in proportion and well supported; pasterns, long, oblique (45°), strong and clean cut; forefeet, large, uniform, slope of wall to be parallel to the slope of pastern; heels, wide; bars, strong; frogs, large; soles, concaved; horn, dense, solid and of good color.

Body.—Withers must be well defined but muscular; the chest and breast wide, deep and well muscled; ribs deep, well sprung, strong and set closely; back must be short, straight, strong and broad; loins, short, broad and strongly coupled; flanks deep, full, long and low under line.

Hindquarters.—The hips must be wide, the croup long, both to be level and muscular; tail well carried; thighs deep and muscular; stifles broad, thick and muscular; gaskins wide and muscular. The hocks should be wide, symmetrical, deep, clean cut, smooth and well supported; the canons and fetlocks like the forehand; the pasterns long, oblique (50°), smooth and strong; the feet not as round as the front, but showing the same characteristics.

Way of Going.—The walk must be straight, strong and active, and the trot powerful, free, with moderate action.

Soundness and Unsoundness, and Improper Conformation.—The technically sound horse is the exception, the serviceably sound the rule, and the true importance of the veterinarian's counsel is not only the mere detection of the unsoundness, but the determination whether the condition exists to such a degree as to interfere with the present or future usefulness of the animal.

It may be well to review some of the various unsoundnesses, such as defective vision and hearing, all abnormalities of the head, face, mouth and jaws, withers and shoulders. All defects of knees like fibrous and bony deposits, thickened tendons, splints, knuckled, ringbones, sidebones, dropped soles, toe and quarter-cracks, contracted heels, and diseased frogs and feet. Abnormalities of back and ribs; old fractures of hips and pelvis; spavins, curbs, etc.

Improper conformation is shown in small eyes, poor shaped head, thin, short neck, axis of body sloping forward, high sharp withers, straight shoulders, narrow chest, shallow lung space, roach-back, sway or hollow-back, calf-kneed, knee-sprung, knock-kneed, bow-kneed, toed-in, toed-out (nigger heels), straight fetlocks and pasterns, crooked hoofs or feet, and sore feet standing too close or too wide at the ground. Barrel tucked up and long coupled; poorly developed loins, hips, croup, stifles or flanks. Sickle-hocked, cow-hocked, bandy-legged or wide at the hocks.

Defects in way of going or gait are forging, interfering, paddling, winging, winding, scalping, pounding, rolling and sluggish walking.

Intelligence and clever walking are essential in horses used in the collection of refuse from house to house. A thorough test of wind is absolutely necessary in every horse and the best manner in which to perform the test is to hook and drive the horse to an ash cart with both wheels blocked; this will bring out any weakness of wind, and after cooling off, any weakness of limbs, particularly stringhalt.

### Care of New Stock.

During acclimatization of the green horses considerable control over the various disease can be exercised by having the animals in a well ventilated stable with an abundance of sunlight. The importance of fresh, cool, circulating air must be emphasized; when the temperature of the stable is almost the same as outdoors there is nothing to fear from the so-called draughts. Instead of closing and opening the windows with the changes in the temperature, simply blanket and unblanket the horses.

The ideal method of managing a sick horse suffering with one of the acclimating diseases is to expose the animal to an abundance of fresh air, even during a snowy or rainy period. The result will be gratifying providing the animal is properly protected by blankets and bandages on the legs. Placing the hand on the flank underneath the blanket one can tell when the horse is too warmly clad, the part being damp with perspiration. When the horse is fevered during a hot spell, sponging the body with cold water 2 to 4 hours will be found very beneficial.

During the trial or breaking in period it is well to have the temperature of all the new horses taken every six hours, morning, noon, evening and midnight, and a record of same kept for reference. The normal temperature of the horse is 100° F., pulse 36 to 40 beats per minute, and respirations 12 to 16 per minute.

Some of the acclimating sicknesses apt to be found in new horses are, distemper, catarrhal fever, strangles, pink-eye, and influenza. Influenza can manifest itself with many complications, such as central nervous disorders, gastro-intestinal disturbances, the pulmonary form causing pneumonia, pleural-pneumonia, endocarditis and pericarditis, and the rheumatic showing soreness and swelling in the various joints.

The market is flooded at the present time with a variety of stock vaccines, sera, and sero-bacterins for curative and prophylactic purposes, the value of which, in the above diseases, are rather doubtful. The best results are obtained in the application of autogenous or insogenous vaccines; that is, where the vaccines are made from the identical strain of bacteria that are the cause of the immediate sicknesses.

Concerning the diet, corn on the cob should be given at different intervals and rock salt kept in the manger. Good alsike clover hay is an excellent roughage for the green horse. In the absence of clover hay, No. 1 or 2 timothy can be given. It may be said that the feeding of bran mashes and steamed oats, due to their laxative properties, are contra indicated in the green horse owing to the tendency of scouring with or without fever during the period of acclimatization. The best diet throughout this period consists of plain whole oats mixed with a certain proportion of alfalfa sweet feed; one part by weight of alfalfa sweet feed to four parts of whole oats is the proportion. Two pounds of this mixture is to be given three times a day, and a daily allowance of 12 lb. of hay; these rations to be gradually increased as the animal is worked. During fever or sickness these amounts above mentioned can be continued if the appetite holds good, or can be decreased according to the indications of the case. But the feeding of sloppy bran and steamed oats is apt to cause greater stomach and intestinal derangement, and eventually bring about a total loss of appetite. Dry oats will not increase the fever as it is commonly thought, but if given in graded quantities will preserve not only the appetite, but likewise maintain the vitality.

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*From a paper presented at the recent Convention of the Society for Street Cleaning and Refuse Disposal by Daniel J. Mangan, Chief Veterinarian, Department of Street Cleaning, New York City.

It is always well to refrain from offering feed of any description for at least 12 hours after the onset of the sickness; this abstinence will serve in restoring the lost appetite, and then when feed is offered give only a small quantity at a time, increasing gradually as the case demands.

When watering green horses in very cold weather it is a good plan to have the chill removed by the addition of hot water. All sick horses must be supplied with individual pails; the reasons for this precaution is obvious. Alfalfa tea is a good drink for fevered horses, one pailful of which is to be given every six hours. This tea is made with ½ lb. of alfalfa hay cut fine and placed in a pail; add 1 gal. of hot water, stir and permit it to stand for 15 minutes and then add enough cold water to fill the pail. Prompt attention should be given to the first sign of scouring or diarrhea in the green horse. A good agent to use is 1 lb. of corn starch in ¾ pail of tepid drinking water, to be given every six hours.

In the shoeing of green horses care must be taken to avoid heavy shoes and to refrain from trimming too much horn off the feet, these precautions with oil meal packing to the front hoofs will prevent founder developing from concussion on the unaccustomed hard and hot pavements of the city.

### Training.

In the training and educating of the horse for street cleaning work, it is necessary that the animal's environment throughout that period be considered. A capable supervising officer with equally capable and courageous drivers and hostlers who know when, how and what to do, will insure perfect results without accidents. The fractious animal must be handled steadily and with judgment, avoiding all abuse in any form, and in the harnessing and hooking, speed, gentleness, and freedom from noise and excitement should be maintained by the attendants.

The best vehicle to use for breaking-in is an uncovered ash cart that is in good condition. The horse must be equipped as follows: A strong halter with a long leader; a strong closed bridle furnished with a four-ring bit and nose strap, and a strong pair of lines. The collar must be a perfect fit, otherwise there is danger in souring the animal's disposition to pull. The hames and chain attachment must be strong and perfectly secured. The saddle pad is to be of proper width and the saddle should have a strong bellyband and girth; the breeching must be in good condition and not fitted too low or tight.

The driver takes his position within the cart and his assistant at the animal's head, having a firm hold of the leader or halter shank, and in this fashion the animal may be driven. One load of material is then collected, the driver to do the loading, and the assistant to hold the horse's head. At the river dumps in New York great care and skill is exercised in gradually acquainting the animal to these strange surroundings. One load a day, or approximating one hour and a half to two hours' work is all that the horse should be asked to do during the first 10 days, after which time the work can be increased to half a day. The longer the animal is kept at half day work the better it will be conditioned and fitted for real arduous labor. Experience has shown that six weeks at half time is sufficient.

The green horse is very soft and tends to perspire easily, therefore great care must be taken to avoid sudden chilling and the usual evil consequences, such as founder, pneumonia, etc. During cold weather a blanket should be used when a stop of any duration is made. When arriving at the stable a good scraping and rubbing with or without a hot bath, and proper blanketing will tend to prevent the above mentioned ailments. At no time must the green animal be required to do any work when its temperature registers 101° or over, or when the weather is very stormy.

The intelligent horse is a very apt pupil and with a steady, clever driver it will finally become an important factor in the rapid collection of refuse, practically stopping and starting of its own accord as each receptacle is emptied into the cart.

Throughout the trial term the stable attendants must keep close watch for signs of the following vices and defacts which are undesirable: kicker, biter, cribber, windsucker, viciousness, weaver, pull-backer, casting in stall, stringhalt and crabbedness of gait.

The presence of wolf teeth is often the cause of shaking the head, refusal to pull or back, driving on one line, rearing and plunging. These supernumeraries are easily removed, after which the animal's actions rapidly become normal.

### The Season Stock.

Stables must be well ventilated with ample sized windows. Box stalls must never be located in the middle of a stable; this point is of prime importance. One or more large, loose box-stalls should be placed in the corners of the stable so as to have sufficient light and air.

Single stalls are to be well drained and should be at least 8 ft. long from hay rack to the heel post and about 5 ft. wide. It is well to have hay racks installed to prevent the waste of hay by pawing horses. Flat feed boxes that are easily removed in order that they may be frequently cleaned are desirable. In stall partitions the planks or panels must be horizontal, with a few inches of open space between each one. A large stable should have several watering troughs, one trough to about every 25 horses.

The forage must be of good quality, such as No. 1 or 2 timothy hay; No. 3-A clipped oats, weighing at least 36 lbs. to the bushel; bran, No. 1 white flake; straw, No. 1 long rye; a high grade of alfalfa sweet feed, and a sufficient supply of salt both fine and rock. The forage allowance varies according to the seasons of the year and the kind of work performed. The daily allowance of rations in July, August, September and October is 21 lb. of oats with 2 lb. of dry bran mixed, and 15 lb. of hay. During the other months of the year, 2 lb. of oats are added to the above allowance, and in extra hard or hilly districts, an additional 3 lb. of hay is given daily. On Saturday nights, to take the place of the dry feed, 7 to 8 lb. of sloppy bran mash with the addition of fine salt should be fed to horses not working the following day. Horses resting on Sunday are fed the full allowance of hay and half of the grain. The quantities given in the daily and Sunday allowance as mentioned may vary according to circumstances. A good grade of clover hay makes an excellent roughage for horses and adds very materially to the condition of the flesh and coat. Corn may be substituted for oats at different intervals during the winter months. Alfalfa sweet feed mixed with the whole oats may be given as a change from the regular diet any time during the year. Crushed oats are advocated by some horsemen and are very good in selected cases. The daily allowance of straw for bedding is about 3 lb. Horses at night work are to be fed the grain ration in the evening, midnight and morning. The allowance of hay is to be given in the morning, thus practically inverting the day feeding.

Watering the horses before meals and not less than 1½ hours after, and then just one pailful, will be conducive to the health of the animal. In a reasonable time after the first post-feeding drink the animal may be permitted to gratify its thirst. Water frequently given during the day will prevent many ills of the horse. A bad practice that is absolutely unnecessary and should be avoided, owing to the danger of causing colics, is the watering of the horse at night after the feeding of hay and oats, the watering of the animal prior to the evening meal being sufficient.

In order to avoid watering the horse at the public troughs, private tubs could be maintained at the dumping points, or each vehicle be equipped with a pail.

Grooming must be well done and this refers in particular to the street cleaning horse who is exposed to all forms of dust and dirt. In winter time the grooming can be followed in the usual manner with the curry-comb and brush, extra attention during snow time being given to the drying and rubbing of wet fetlocks. In the hot weather it is very difficult to groom owing to the moist hide caused by perspiration. This can be overcome when the horse arrives at the stable at the end of its day's work, by washing it thoroughly with water heated to about 110° F. This washing must be followed by good scraping with a metal scraper. In addition to the cleansing effect of the bath, it will be found very refreshing and cooling to the overheated horse. Never use cold water for the bath. Cold water is used only on horses suffering from heatstroke and then is applied to the head, between the ears, under the groin and into the rectum. Cold water on the body of an overheated horse invariably causes laminitis or founder.

Clipping the horse that has an extra heavy coat will help keep it in better condition and is also very good for the poor summer or heat horse, regardless of how fine and light its coat may appear. Clipping the fetlocks should be prohibited, especially during the winter and in horses working in land dumps. The feathers of the fetlocks serve as a very important protection against the irritating properties found in mud, slush, snow, etc.

The use of stable blankets helps to permit suitable ventilation of the stable in cold weather, and it is a known fact that when the temperature and atmosphere in the stable is almost the same as that of out-doors, the horses therein are more capable of performing their hard work with greater vigor. The woolen blanket during winter can be folded and suspended either on the manager of the cart or hames of the collar, and must be used when the horse stands or is idle, as at feeding, delay at the dumps, or when the weather is extremely cold and the collection of material is slow. The blanket should never be spread on the horse while it is in active motion. The three-quarter or so-called kidney blanket should be discarded owing to its tendency of developing weakened conditions in that region.

Good harness and properly applied is an important factor in the maintenance of the horse's working powers. Poor, worn-out and ill-fitting collars are prolific in the production of sore necks and shoulders. Dirty, hard and small saddle pads are the principle causes of sore backs. Saddle and collar galls should be kept perfectly clean and free of scabs. This precaution with the avoidance of the use of so-called drying powders will facilitate healing and repair. The use of powders and astringent ointments encourages scab and sitfast formations, thus interfering with the proliferation of new skin cells from the healthy periphery of the sore.

Horseshoeing is another very important item in the horse's upkeep. The regularly worked horse should be shod with new shoes on the four feet at least once a month. Horses working on squeegees, watering carts, and sweeping machines should be equipped with rubber pads on front and hind feet. All horses working on the collection of refuse should be shod with leather soles or similar hoof protectors, and the hoofs packed with tar and oakum. These protectors will materially reduce the percentage of injured feet caused by nails, glass, and other foreign objects. Pads on the front feet are of great value in prolonging the usefulness of tender or sore-footed horses. The most serviceable shoeing for the snow and slippery period is pads on the front feet, the tip to be "roughed" calked. The toes and heels of the hind shoes must be "roughed" calked. None of the various anti-slipping devices observed possess any practical merit.

The following diseases can be controlled in a large measure by proper management and supervision: Most of the gastro-intestinal disorders (colics), azoturia, heat stroke, cerebro-spinal meningitis (so-called forage poisoning), and septic poisoning, from nail, calk, and other wounds.

## SOME COSTS OF FLUSHING AND SCRUBBING PAVED STREETS AT ST. PAUL, MINN.

The equipment used by the Bureau of Sanitation of St. Paul, Minn., for flushing and scrubbing paved streets consists of five Studebaker power flushers, two 2-horse-drawn Hvass squeegees, one 2-horse Kindling squeegee and one 3-horse Hvass squeegee. According to the annual report of M. N. Goss, Commissioner of Public Works, the area of paved streets flushed and scrubbed in 1915 was 1,493,000 sq. yd. This does not include the pavement laid in 1914 or 1915 on which very little flushing was done in 1915. The cost of this service was as follows:

| | | |
|---|---|---|
| Team hire | $6,359 | |
| Labor | 2,704 | |
| Gasoline, [illegible] gal. | 912 | |
| Lubricating oil | 123 | |
| Water (32,145,850 gal.) | 1,286 | |
| Repairs | 1,469 | |
| | | $12,687 |
| Miscellaneous labor | 357 | |
| 4 new engines for flushers | 1,400 | |
| 1 Hvass squeegee | 950 | |
| 1 Kindling squeegee | 1,200 | |
| | | 3,907 |
| | | $16,592 |

The Street Railway Co. paid its proportion of this cost which was 24.2 per cent, or the ratio of the street railway area to the entire area of streets flushed.

In the congested business district bounded by St. Peter St., Eighth St. and Third St. and Broadway all streets are flushed every night during the season. This district comprises 7.12 miles of streets or an area of 146,400 sq. yd. The crew consists of one foreman, three teams at 60 ct. each per hour and two gutter cleaners at 25 ct. each per man. The cost of one night's flushing (8 hour shift) in this district amounts to $27.61. This includes gasoline, lubricating oil and water, but not repairs, interest or depreciation. This is 19 ct. per 1,000 sq. yd. for one flushing. The flushers are used on the day shift on streets outside of the so-called congested district. The day shift work nine hours. Paved streets are flushed or scrubbed at least once a week during the season.

As a matter of comparison of cost, the W. Seventh St. district, with an area of 89,700 sq. yd., 68,000 sq. yd. of which is sandstone, on the level, with street car tracks and very heavy traffic and with intersecting traffic streets as follows: 8,500 sq. yd. of asphalt, 10,800 sq. yd. of creosoted wood block and 2,400 sq. yd. of brick, costs for one flushing $39.80 or 44 ct. per 1,000 sq. yd. This district is flushed once a week and is one of the hardest districts to clean.

The E. Seventh St. district with an area of 150,400 sq. yd., of which 109,800 sq. yd. are brick, steep gradient, street car tracks, automobile traffic and light miscellaneous traffic with intersecting streets as follows: 25,600 sq. yd. of asphalt and 15,000 sq. yd. of sandstone, cost for one flushing $43.56 or 29 ct. per 1,000 sq. yd. The crew in each of the above cases was one foreman, three teams and two gutter cleaners working one 8-hour shift.

The squeegees are operated only in the day time on smooth pavements, such as creosoted wood block or asphalt. The 3-horse squeegee scrubs 42,000 sq. yd. of pavement in one 9-hour shift and uses 11,000 gal. of water, the resulting cost being $17\frac{1}{2}$ ct. per 1,000 sq. yd. scrubbed. The 2-horse squeegees do a slightly less amount. The total amount of water used for street flushing purposes during the 1915 season was 32,145,850 gal. for which the department was charged $1,286.

## NECESSITY FOR LIMITING THE LOADS, SPEED AND SIZE OF VEHICLES.

Excessive damage to pavements in the Borough of Manhattan, New York City, during the past year by heavily loaded steel tired trailers hauled by motor trucks has brought to the attention of the authorities the necessity for limiting the loads hauled on city streets. The situation was described by Mr. Eugene W. Stern, Chief Engineer in Charge of Highways, Manhattan Borough, in a paper presented on Oct. 11 at the convention of the American Society of Municipal Improvements. The matter that follows has been taken from Mr. Stern's paper.

The most damage seems to be caused by steel tired vehicles hauled by motor trucks. A case in point is here given: A contractor's outfit hauling rock from the subway excavation on Broadway is made up of a tractor and trailer. The latter carries six large buckets, weighing about 15 tons. Its wheels are 41 in. in diameter with 8½-in. wide steel tires. The load per inch width of tire is about 1,400 lb. There are 10 of these trucks in operation. They work 16 hours per day and each makes about one trip every hour. The total number of trips, therefore, for the 10 vehicles is 160 per day.

The springs on the front axle are spiral and on the rear, flat. They are very stiff, and this fact has unquestionably contributed towards the destructive effect of the wheel loads of the trailer. The jarring effect of the loaded vehicle is such that people along the route traveled complain about excessive vibration in their buildings.

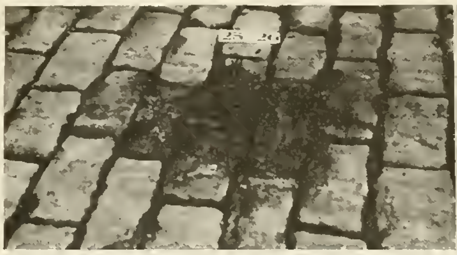
Fig. 1—Wearing Off of Granite Blocks.

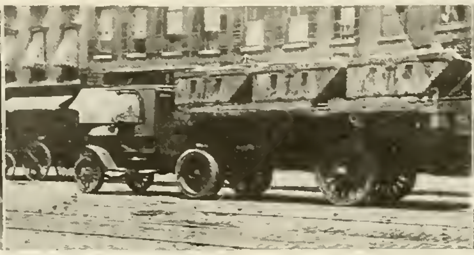
Fig. 2—Type of Heavy Trailer.

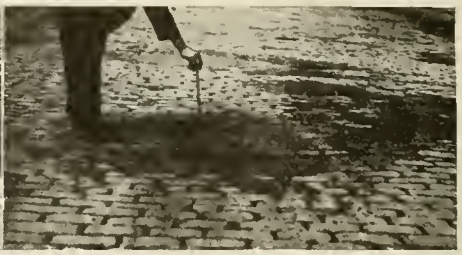
Fig. 3—Damage to Granite Block Pavement.

The route traversed has been over sheet asphalt on concrete foundations and improved granite block on concrete foundation. These pavements are substantially about four years old. They are considered among the best pavements in the city, and have been laid in conformity with the latest specifications. Up to the time when the damage began to be done by the above mentioned trailers, no appreciable amount of wear had been noticed beyond what ordinarily might be expected on thoroughfares with as much traffic as have the streets above mentioned.

The mischief has all been done in a very short space of time (about nine months), and has amounted to 5,400 yd. of repairs on granite (equal to 32 per cent of the total area), costing $6,000, and 1,900 yd. of repairs on sheet asphalt (equal to 30 per cent of the total area), costing $1,900; whereas, prior to this time, the average cost per year of maintenance on the granite was $150, and on the sheet asphalt $70.

On granite pavements the granite blocks have been literally crushed and ground into powder. In many cases the blocks were split. The granite used has given splendid service on other streets of the city. Table I gives some details of the granite paving on the route and the percentage of repairs.

TABLE I.

| Location. | Quarry. | Crushing strength, lb. per sq. in. |
|---|---|---|
| 42nd St., 9th to 10th Ave. | North Jay, Me | 20,000 |
| | Percentage of Repairs: | |
| | 1915 .4 | |
| | 9 months of 1916 45.0 | |
| 10th Ave., 42nd to 50th St. | Rockport, Mass. | 25,000 |
| | Percentage of Repairs: | |
| | 1915 .5 | |
| | 9 months of 1916 26.0 | |
| 50th St., 11th to 12th Ave. | Salisbury, N. C. | 40,000 |
| | Percentage of Repairs: | |
| | 1915 .6 | |
| | 9 months of 1916 36.0 | |

On the sheet asphalt, the destructive effect has been equally startling. In some places it has been ground to small bits; in other places the wearing surface has been completely broken and cracked. It shows many depressions, waves and ruts and shoves.

In many cases the 6-in. concrete base has been shattered; however, in many other cases where the wearing surface has been damaged, the foundation remains intact.

The speed of these vehicles was about 6 miles per hour in the day time, and at night it was considerably higher—12 and 14 miles per hour, and even 16 at times.

The effect of rubber tired traffic has been carefully investigated, and practically no damage has been caused by motor vehicles in which all of the wheels are covered with rubber, beyond what is reasonable, although there are some types of heavily loaded trucks in use in the city. The first-class pavements show practically no additional expense for maintenance beyond a reasonable amount.

The manufacturers of motor vehicles have found by experience that about 750 lb. per inch width of tire is about all the load the rubber tire will stand, and this load, together with the resiliency of the rubber and the adequate springs on motor vehicles which good construction demands, seem both together to be the saving features in protecting the pavements against undue wear, even under heavy loads.

It would appear that regulations properly framed to protect the pavements against the destructive effects of excessive loading in vehicles, should take into account the following factors:

1. That the wearing or damaging effect of wheel loads on pavements is a function of (a) the load; (b) the diameter of the wheel; (c) the width of tire; (d) whether or not the tire is of a resilient material such as rubber, or of steel; (e) the kind of springs.
2. That speed has considerable to do with the damaging effect of heavy loads.

An investigation of the laws and ordinances governing the weights and loads of vehicles, etc., adopted by eight states and 49 cities in the United States and Europe, goes to show that only a few laws have been drafted in accordance with modern conditions. It is surprising that even today in this country, certain communities require that the width of the tire should depend on the diameter of the axle, regardless of the loading; others make no distinction in the regulations between a wheel large or small in diameter, while still others treat rubber and steel tired wheels the same.

Requirements of some of the most up-to-date ordinances are shown in Table II.

Mr. Stern believes that unless some limitation is placed upon the size of vehicles, the tendency will be to make them larger and larger, until they will become a nuisance and congest the highways. This is now becoming evident in the city of New York, as well as in other cities.

In order to provide reasonable standing room on each side of a street, and at the same time allow traffic to proceed in both directions, it is necessary to limit the width which vehicles take up.

Many of the streets have roadways only 30 ft. between curbs. It thus becomes evident that vehicles over 7 ft. in width do not allow for two to pass, even using

TABLE 11.

- Chicago, Ill.:
  - Maximum weight of vehicle, 15 tons.
  - Maximum load on any one axle, 12 tons.
  - Maximum load on the wheel, 6 tons.
  - Maximum load per inch width of tire, 1,000 lb.
  - Maximum length, 40 ft.
  - Maximum width, 8 ft. 6 in.
  - Speed: Compatible with safety, but not to exceed 9 miles per hour. Not to exceed 4 miles per hour when truck has defective tire which would cause injury to pavement.
  - Motor trucks must have rubber tires.
  - Trailers may have steel tires.
- New York State:
  - Maximum weight of vehicle, 14 tons.
  - Maximum load on any one axle, 9 tons.
  - Maximum load per inch width, 800 lbs.
  - Maximum width, 8 ft. 4 in., except traction engines, which may have width of 9 ft. 2 in.
  - Speed: Over 4 tons, 15 miles per hour; over 6 tons, 6 miles per hour with steel tires, 12 miles per hour with rubber tires.
- State of New Jersey:
  - Maximum weight of vehicle, 12½ tons.
  - Maximum load per inch width of tire, 800 lbs.
  - Speed: 4 tons, 12 miles per hour iron tires; 6 tons, 8 miles per hour iron tires, 10 miles per hour rubber tires.
- State of Pennsylvania:
  - Maximum weight of vehicle, 12 tons.
  - Maximum load on any one axle, 9 tons.
  - Maximum load per inch width of tire, 750 lbs.
  - Maximum width, 7 ft. 6 in.; for busses in large cities, 8 ft. 4 in.
- State of Massachusetts:
  - Maximum weight of vehicle, 14 tons.
  - Maximum load per inch width of tire, 800 lbs. (except for hard pavements).
  - Speed: 4 tons, 15 miles per hour; 6 tons, 6 miles per hour iron or steel tires, 12 miles per hour rubber or similar tires.
- Oakland, Cal.:
  - Maximum weight of vehicle, 14 tons.
  - Maximum load per inch width of tire, 800 lbs. (except for hard pavements).
  - Speed: 4 tons, 6 miles per hour iron or steel tires, 12 miles per hour rubber tires.
- England:
  - Maximum weight of vehicle, 12 tons.
  - Maximum load on any one axle, 8 tons (for trailers, 4 tons).
  - Maximum weight of vehicle without load, 5 tons.
  - Combined weight of motor car and trailer, 6½ tons.
  - Weight on axle to be proportioned to diameter of wheel.
  - The load per inch width of tire (steel) shall be 840 lbs. for wheels 3 in. in diameter; and an additional allowance of 9⅓ lb. for every additional increase in diameter beyond 3 in.; and for wheels less than 3 in. in diameter a deduction of 18⅔ lb. per inch width of tire for every inch less in diameter than 3 in.
  - Vehicles for military service limited as follows:
    - Weight of car unladen, 6 tons.
    - Weight of car with trailer, 8 tons.
    - Unit of registered axle weight with tires shod with cross bars, 560 lb.
  - Maximum width, 90 in. for 3 tons; 90 in. for trailer.
  - Speed: Dependent on axle weight for iron-tired vehicles; 6 tons, 12 miles per hour for rubber tires; over 6 tons, 8 miles per hour for rubber tires.
    - Should car unladen weigh more than 3 tons, speed is limited to 8 miles per hour.
    - If motor draws trailer, miximum speed is 5 miles per hour.

the utmost care. While it is becoming necessary to widen roadways in Manhattan Borough, it is very difficult to add more than 2 ft. to each side; a 30-ft. roadway is thus converted into a 34-ft. roadway. In this case a 7½-ft. width for a vehicle would be the limit.

## SURFACING OLD BRICK PAVEMENT WITH SHEET ASPHALT.

About 4 years ago the city of Columbus, O., began surfacing some of its old brick pavements with sheet asphalt. These old pavements were laid on a gravel, a crushed stone or a creosoted plank and sand foundation. The brick were small size red brick and the joints were either tar or sand filled. In 1912 three of these old streets having an area of about 14,000 sq. yd. were surfaced over with sheet asphalt. Since that time nine other similar streets have been given a similar treatment and the total yardage has been increased to about 75,000 sq. yd. The following description of the methods employed in this work is taken from a paper by T. H. Brannan, superintendent of asphalt construction for the city of Columbus, presented at the recent convention of the American Society of Municipal Improvements:

One of the first questions to be considered in this kind of construction is that of drainage. All of the old streets were laid with a 6-in. gutter. After a 3-in. coat of binder and top has been put over the old brick, it therefore leaves a very shallow gutter. On streets having a lateral grade of 0.6 per cent, or over, this is not so serious, but for grades less than 0.6 per cent, a 3-in. gutter may not be deep enough to carry the water. On these streets one of two things can be done:

The first method is to take up the old brick in the gutters for a width of 3 to 4 ft. from the curb and lay a concrete base to such a grade that when the gutter is paved with new brick these bricks will be high enough at the outer edge to form a shoulder for the edge of the asphalt.

The second method is to take up the old brick for a distance of 3 to 4 ft. from the curb, concrete this space leaving it low enough along the curb to lay asphalt over and still maintain a desired depth of gutter. The outer edge of the concrete can be brought to the level of the old brick and an asphalt roadway can then be laid from curb to curb. This will increase the transverse grade or crown of the street near the curb, but not enough to be seriously objectionable.

Before any asphalt is laid on old brick it is essential that the old brick pavement be cleaned and all of the dirt removed from the joints to a depth of at least ½-in. This is done most effectively by flushing with a fire hose. It can also be done by raking out the joints with sharp pointed picks, or hooks, and then sweeping. If flushed, it is necessary to give the street some time to dry out and for this reason the sweeping is preferable during the late fall months.

In case the old brick are worn through at any point or are more than 3-in. below the general grade, these holes or depressions are cleaned out and concreted. At intersecting streets it is necessary to either go back to the property line a few feet and relay the brick, bring them up enough to form a shoulder for the asphalt at the lot line, or take up the brick in the wing and let the new asphalt pavement down enough to meet the existing pavement on the cross street.

A closed binder containing from 20 to 25 per cent, of material passing a 10-mesh sieve is preferable to a paint coat. A paint coat of asphalt must be cut back with naphtha in order to apply it and unless this naphtha entirely evaporates before this is laid it is likely to work up through the top and be detrimental to the pavement. The large variation in the thickness of the top, however, would be the greatest objection to the paint coat. The wide tread roller bearing on the different depths of top will compress the thinnest portion and leave the deep spots only partially compressed. Trucks going over the pavement after it is completed will further compress the deep spots and form depressions in the pavement. The depressions thus formed will likely produce shoving and destroy the pavement.

A 1½-in. top and 1½-in. binder are used on these streets. The 1½-in. binder is figured on the basis of 1 cu. yd., box measurement laying 20 sq. yd. Whatever excess there is over this amount is paid for by the cubic yard as extra binder.

Where the brick foundation is very irregular the binder is laid in two courses. The depressions are first filled and rolled and then the 1½-in. binder is laid. An examination of the underside of a slab of binder taken from a cut on a resurface job of this character showed the print of all the brick and also showed the binder driven in between the brick sufficiently to give a good bond.

The average amount of binder required on all the streets that have been laid was .022 cu. yd. per sq. yd. of top. This at $7 a cu. yd. would be an item of about 15 ct. a sq. yd. for extra binder. This amount plus 5 ct. a sq. yd. for cleaning deducted from the cost of excavation and new concrete represents the saving that can be made on this kind of construction. In Columbus with concrete figured at 70 ct. a sq. yd. and excavation at 95 ct. a cu. yd. this saving would amount to 75 ct. a sq. yd. of finished pavement.

Three of the streets resurfaced 4 years ago are within four blocks of the center of the city, and are stated to be in as good condition as if they had been laid on a concrete base. They are not cracked, have not shoved, and have not had and do not need any repair. The nine streets resurfaced since 1912 carry a somewhat lighter traffic and would be classed as residence streets. They are stated to be in good condition and have had no repairs.

## HOW TO CONDUCT A BOND CAMPAIGN.*

Photographs of inefficient machinery and its cost of operation are shown by stereopticon slides, followed by one showing efficient equipment and the saving in operation costs. Alleys showing outhouses, garbage piles, ash heaps, etc., make good illustrations of the lack of sewers and sanitation and contrast this with stereopticon slides showing abandonment of alleys with the installation of sewers with its beautiful back yard flower-beds and creek banks beautified.

Health statistics graphically shown on a slide of your own city, even showing poor results and you are ashamed of them, serve to stimulate an interest in bettering the conditions. Slides showing the typhoid rates of other cities with pure water supplies emphasize the need of action in your own city. Typhoid and many other water borne diseases are preventable diseases, preventable by proper precaution in water supply, food and sanitation.

The time is fast coming when the sheriff and police officers will investigate and fix the responsibility for every case of a preventable disease. Dr. Hazen, an authority, says for every case of typhoid some one ought to be hanged. The real town booster gains nothing by covering up and minimizing the town's sore, festering and ugly spots, but let them be known and the town will soon have none of these to apologize for.

Proper publicity and presenting of engineering reports needs no exaggeration to make the arguments effective, but a real portrayal of plain facts by slides and moving pictures merely brings to the attention the need of improvements, and where the necessity is shown, the cash is always forthcoming.

During a campaign for sewers and a modern sewage disposal plant recently the writer found the moving picture shows all anxious and willing to show such films as "The Daily Life of a Fly"; also, the public meetings were packed to see the plans and estimates shown on the screen, illustrating the proposed improvements, together with pictures showing the best examples of similar improvements in other cities.

There is no municipal improvement that cannot be graphically illustrated by pictures and diagrams and they are plainer than printing or typewriting. Maps showing water or sewer lines, with their sizes and locations, can be shown by slide. White-way or ornamental lighting can be well illustrated. The writer has conducted successful campaigns for bonds by this method, covering such a variety of subjects as the following:

Campaigns for municipal ownership of water works and lighting, for sewers and sewage disposal plants—new water supplies, filtration systems, water power, park and street improvements.

It is an unfortunate fact that many a needed public improvement is delayed to the point of criminal negligence on the part of those in authority, solely on account of their fear that public sentiment may be against the improvement.

The Superintendent of the city water works may know that the water supply is inadequate or that the pumping machinery is insufficient to give fire protection, and he may confide this alarming situation to the other city officials, only to be told to keep the matter hushed up as they do not dare ask the people to vote bonds until after the spring election and they will try to pinch along another season on their present equipment. They are willing to gamble against Fate. They take a chance and sometimes they lose, or, rather the public loses property worth many times what the water works improvements would have cost; and that is not all—the public then awaken to the necessity and rebuilds its water plant—and if justice falls where due, the public also selects new city officials. But this illustration pertains only to property loss—material things. I have in mind a far worse negligence—criminal without a doubt, but wholly due to the fear of taking the public into the confidence of those responsible for public property. This is a case where a city is supplied with pure water, but the plant facilities are not adequate to meet the requirements of the dry season, and as a consequence of this condition of affairs it becomes necessary to introduce polluted river water into the city mains at times during the hot summer season. The Superintendent of this waterworks system told me he was simply "up against it" and he did not dare mention the true situation publicly for fear of the storm of indignation that would fall upon him. And yet this city failed to vote bonds for an increased pure water supply when the question was submitted to a vote. The reason it failed was plainly due to the fact that the city officials did not have any definite plan prepared to show how they proposed to use the money, nor did they make any organized campaign to educate the public to the necessity of the improvement. Now, I need not tell you the name of the town where this occurred. Perhaps some of you are afraid I will name the town and cause you to be embarrassed. If you feel that way, my advice is that you go home with a firm determination to shoulder your share of responsibility for public health and see that your city is not one of those that may suffer from your continued negligence.

The average engineer's report on improvements is too long, dry and technical and frequently leaves the officials in the air as to what to do next. The real job of raising the funds is as much the engineer's obligation as showing how much is needed.

Many municipalities make the mistake of proceeding with a bond issue without first having an experienced engineer's report covering cost, comparison of various features and recommendations about the project, with the result that when voters are asked for bonds, the questions the voters ask about the project cannot be intelligently answered and the officials are put in a defensive position and the voters are groping in the dark as to some phases of the question. Then again, the cost, or amount of bonds, will be questioned unless it is based on a very carefully made plan and estimate.

A wrong impression or conception of a project often defeats it. The voters have a right to know and should know every detail of the project before voting.

The correct cost and proper explanation of the project, or the first impression of it, is the lasting one and this should be given at the outset and not after there are hundreds of half baked opinions spread broadcast regarding the projects. An engineer's greatest value to the community comes in by properly conceiving the character and extent of the work before a bond election and like the skilled diagnostician in studying the symptoms, the causes, etc., he can prescribe correct treatment before mistakes are made. Cities often fail to realize that it costs no more for an engineer's services right at the outset than it does to call him in after funds are provided.

An improvement that may apparently seem dry and uninteresting can in this way be made such a live interesting subject that civic organizations, women's clubs, labor unions, etc., are seeking an illustrated talk before their organizations, which not only instructs but entertains. How many people nowadays would go to hear a paper read or a lecture, even if ably presented? The public like to see as well as hear, and to see by slides what their neighboring cities are doing helps to do better our own problems.

This method, of course, involves much added work for the engineer but it is worth while, at least in the satisfaction that comes from a consciousness of a public duty discharged to the best of one's ability. A study of this subject has led us to adopt the graphical method of presenting everything that can be pictured. The results have been gratifying and show that in the last two years thirty projects have been handled in this manner without a single bond defeat, although ten of the projects had previously met defeat before the illustrated bond campaign had been applied—however, the greatest result of all comes in the fact of a better citizenship, a lessening of the general and typhoid death rate through better water supplies or sewerage, and an awakened civic pride.

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*From a paper by R. E. McDonnell of Burns & McDonnell, Consulting Engineers, Kansas City, Mo., presented before the recent eighth annual meeting of the Kansas League of Municipalities.

## A LOW COST REINFORCED CONCRETE PAVEMENT.

A 6-in. 2-course reinforced concrete pavement was laid at Joplin, Mo., in October, 1915, at a cost to the city of 1.18½ ct. per square yard. This price includes excavating, headers, protection during curing, in fact, the pavement complete. The pavement was laid on 7th St., which connects with a section line road to the east over which much heavy traffic passed to nearby towns and mines. A census showed 1,500 vehicles in 12 hours, about half of which were motor driven.

The stone used in concrete in this district is a by-product of the mines; a flint of a rather brittle nature and of sizes shown by the sieve analysis:

| Mesh sieve. | Per cent passing. |
|---|---|
| 2 | 100.00 |
| 4 | 96.64 |
| 10 | 83.78 |
| 40 | 50.90 |
| 80 | 27.30 |
| 200 | 4.74 |

The voids in this aggregate ran about 20 per cent, so that a mixture of 1:4½ was adopted for the pavement.

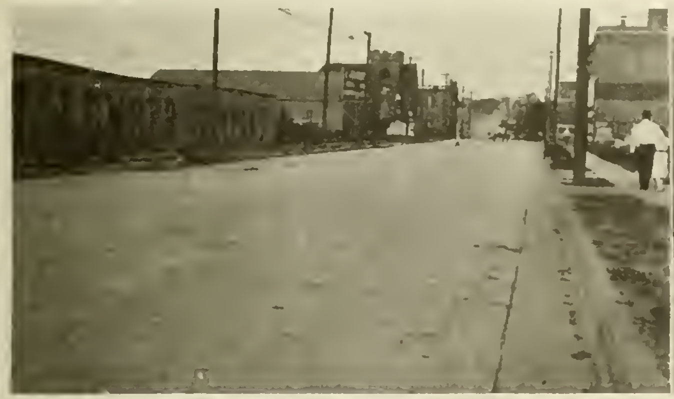


Fig. 1—View of 7th St., Showing Longitudinal Expansion Joint Along Gutter.

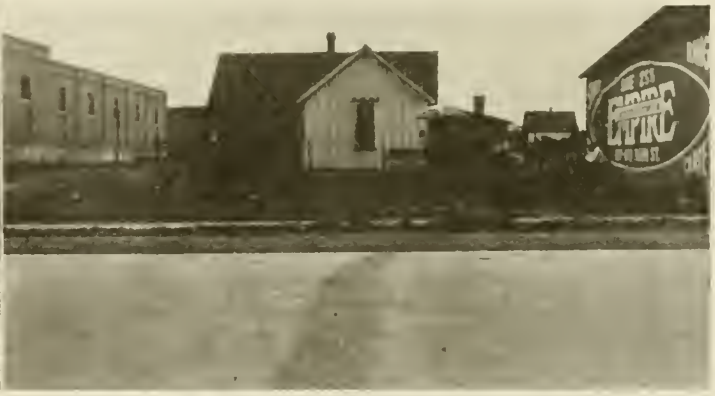


Fig. 2—Showing Well Protected Transverse Expansion Joint.

Due to the brittle nature of the stone this mixture would not stand up as a wearing surface, so a second course of a finer aggregate known as Chitwood sand, also a mine product, was adopted and the proportioning used was 1 to 1½. The first course was fixed as 4½ in. thick and the finish course as 1½ in.

The reinforcement mesh selected conforms to the suggestion of the First Proceedings of the National Conference on Concrete Road Building & American Wire & Steel Co.'s No. 27 trangular mesh was used.

Before construction was under way a storm sewer was constructed and all water and gas mains and services were put in first-class condition to insure no excavations through the pavement, for some time at least.

The excavation was light, not over a foot of old macadam being removed in the heaviest work. Teams were used on most of the plowing, a traction engine breaking up the harder ground in 2½ days. The subgrade was then rolled with a 15-ton roller and any soft or spongy places that developed were excavated and filled with solid material. The materials for paving were then hauled to the sides of the street and the side streets along the line of work, the mesh being placed in the parkways on either side of the street.

The concrete was mixed in a low charging, ½-cu. yd. Standard mixer, the material being run up on a platform in wheel-barrows and dumped directly into the drum and the mixed concrete was carried away in buggies. About a 6-ft. row of the first course was carried across, brought to grade, then another, and after about 15 ft. had been laid, the mesh was placed. The finish course was then run through the same mixer and placed immediately on top of the mesh. This procedure was carried forward for 25 ft. to 36 ft. and a board placed as a temporary header. After the concrete had been brought to grade up to this point the header was removed and a layer of Ruberoid roofing placed against the concrete and the next section was laid immediately against this. A joint was made at the end of the day's run, which was about 100 ft. of pavement 36 ft. wide, and joints were carried for the length of the street along both gutters.

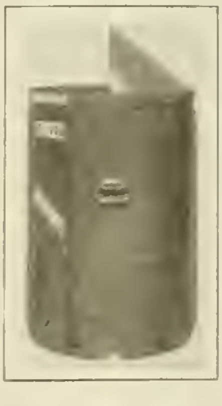
The wire mesh was laid with a 2-in. lap and scraps of the rolls were used in the alley pockets. The surface was finished with a long-handled wood float, care being exercised that no stroke marks remained and yet with no attempt to secure a sandpaper finish. The paving gang averaged 16.5 men for the job. Of these two were finishers and one the mixer engineer. The first work of the morning was to cover the section that had been run the day before with sand and thoroughly sprinkle it. At all times before opening to traffic the pavement was protected in this way.

After curing 14 days the pavement was opened to traffic. The street was completed in twenty-five days and opened about two weeks later.

The pavement has been down about a year now and has fulfilled all expectations. There are no cracks and the surface shows no appreciable wear. The only maintenance charge during this time has been for covering the expansion joints with asphalt, which has completely protected them from all wear. V. E. Koch of Joplin was the successful bidder on this work, securing the job, 6,909 sq. yd., at $1.18½ per square yard. The city has awarded contracts for 32,450 sq. yd. of this pavement for the present year.

## RUBBISH RECEPTACLE, BUREAU OF HIGHWAYS, PHILADELPHIA, PA.

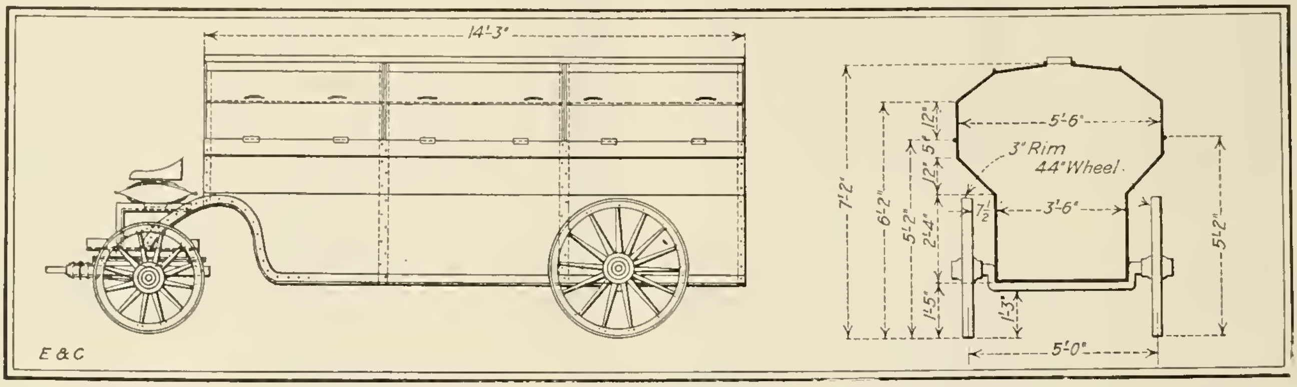
The Bureau of Highways of Philadelphia, Pa., has recently awarded contracts for the supply of highway rubbish receptacles of the type shown in the accompanying half-tone. The bottom of the can is made of No. 20 gage sheet iron with a 1-in. flange riveted to the body and through a 13-ounce steel band 1¾ in. wide. The bottom plate is so placed that an air space of 1¾ in. in depth exists between the surface of the pavement upon which the receptacle rests and the under surface of the bottom plate. In order to provide for proper drainage, the bottom plate shell is perforated with 20 holes, ½ in. in diameter, uniformly distributed over the bottom plate area. The bottom band contains 4 semi-circular openings 1 by 2 in. in size placed at equidistant points.



The protection hood overlaps the body 10 in. from center, and is 8 in. high above the top of the receptacle. The receptacle is reinforced by eight upright 3-ribbed steel staves made of No. 24 gage sheet iron riveted to the top and the bottom bands of the receptacle. The notices "For Waste Paper and Refuse," "Help Us Keep the Streets Clean," and "Bureau of Highways, D. P. W.," are stenciled in white letters on the front of the receptacle.

## SPECIAL DESIGN OF WAGON FOR REFUSE COLLECTION.

Since the reorganization of the Department of Health of Dallas, Tex., in May, 1915, considerable time has been devoted to developing a sanitary method of collecting and transporting the city refuse; special attention being given to the type of refuse wagon. The results of this work are embodied in the accompanying sketch of an improved refuse collection wagon which was recommended recently to the Board of City Commissioners for adoption. The design was made in the Department of Public Health under the immediate direction of H. W. Van Hovenburg, chief of the Division of Engineering and Administration. It is estimated that a well constructed wagon built according to this design will cost approximately $300. The wagon has a capacity of 284 cu. ft., and is built with cut-under wheels in front so that it can turn round in a very limited space. It should be noted that conditions at Dallas are such as to make the use of motor driven vehicles impracticable for refuse collecting. The above note has been taken from a paper presented at the recent convention of the American Society for Municipal Improvements by Mr. Charles Saville, director of public health, Dallas.



End and Side Views of Special Design of Wagon for Refuse Collection at Dallas, Tex.

## DISTRIBUTION OF 1915 EXPENDITURES OF STATE HIGHWAY DEPARTMENTS.

The accompanying illustration, reproduced from a circular prepared by the Division of Road Economics of the Office of Public Roads and Rural Engineering, and issued last month by the U. S. Department of Agriculture, shows the percentage distribution of road expenditures during 1915 under supervision of State Highway Department. Comparison covers construction, maintenance, engineering, administration and miscellaneous. The variations, especially in the items of administration and engineering, as shown in the cut, are probably due more to differences in bookkeeping and definition of what items should be included under this head than to any other cause.

The expenditures during 1915 under the supervision of these State Highway Departments were as follows:

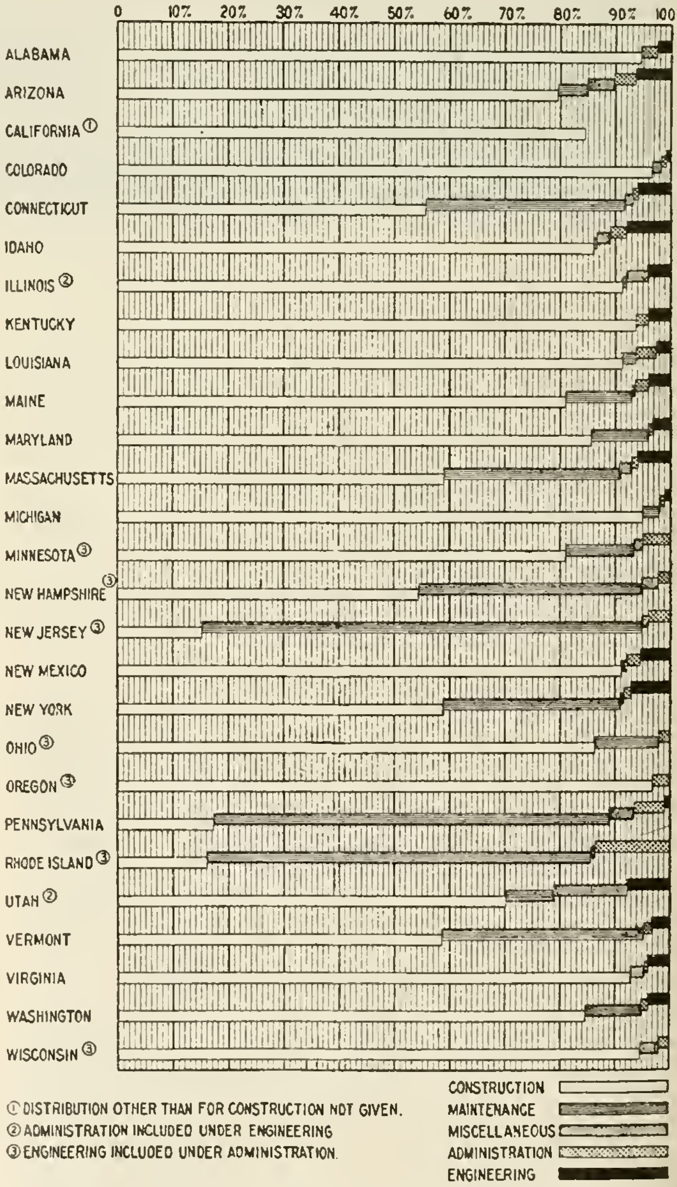
| State. | Source of funds State. | Source of funds Local. | Total. |
|---|---|---|---|
| Alabama | $ 126,134 | $ 172,613 | $ 298,747 |
| Arizona | 476,178 | ....... | 476,178 |
| California | 8,301,149 | ....... | 8,301,149 |
| Colorado | 203,000 | 370,000 | 573,000 |
| Connecticut | 2,084,944 | 150,000 | 2,234,943 |
| Idaho | 200,000 | 274,636 | 474,636 |
| Illinois | 818,638 | 945,357 | 1,763,994 |
| Kentucky | 573,715 | 548,715 | 1,122,430 |
| Louisiana | 144,821 | 424,889 | 569,709 |
| Maine | 1,009,345 | 409,556 | 1,418,901 |
| Maryland | 3,330,000 | 300,000 | 3,630,000 |
| Massachusetts | 2,634,567 | 602,712 | 3,237,279 |
| Michigan | 975,000 | 2,349,738 | 3,324,738 |
| Minnesota | 1,580,000 | 2,462,000 | 4,042,000 |
| New Hampshire | 666,339 | 447,084 | 1,113,413 |
| New Jersey | 1,163,308 | 4,000,275 | 5,163,583 |
| New Mexico | 152,122 | 47,788 | 199,919 |
| New York | 13,983,769 | 2,521,870 | 16,505,648 |
| Ohio | 3,442,604 | 3,442,604 | 6,885,207 |
| Oregon | 230,000 | 410,000 | 640,000 |
| Pennsylvania | 6,541,257 | 745,171 | 6,541,257 |
| Rhode Island | 204,119 | ....... | 204,118 |
| Utah | 121,000 | 342,100 | 463,100 |
| Vermont | 485,145 | 265,000 | 750,145 |
| Virginia | 526,645 | 1,718,754 | 2,245,398 |
| Washington | 1,435,020 | 1,235,683 | 2,670,702 |
| Wisconsin | 1,389,515 | 3,071,465 | 4,460,980 |

## EXAMINATION QUESTIONS FOR COUNTY ROAD ENGINEERS IN KENTUCKY.

The Department of Public Roads of Kentucky on Sept. 28 held an examination to secure eligibles for appointment as county road engineers. The following is a list of the questions asked:

Question 1.—How many cubic yards are contained in a car when level full which has the following dimensions: 36 ft. long, 7 ft. wide and 4 ft. 6 in. high?

Question 2.—How many cubic yards of broken stone, loose measurement, are required to build one mile of road 16 ft. wide and 8 in. deep compacted?



Percentage Distribution of Road Expenditures Under Supervision of State Highway Departments During 1915.

Question 3.—Under average conditions, about how many men are required to economically operate a rock crusher which has a capacity of 100 cu. yd. per day? Show in detail the number of men required in the quarry hauling the rock to the crusher, etc., and about what would be the cost per day for labor, teams, fuel, etc.

Question 4.—In the grading of a road one mile long a hill at one end is to be cut down to a fixed grade, the earth is to be moved and spread at a uniform depth over the entire length of the road, you have wagons, drag scrapers, carts and wheel scrapers with which to remove the earth, show by sketch and rough figures what portion of the road you would grade with the respective implements.

Question 5.—In resurfacing an old telford pike the new material (a fair grade of broken limestone) when spread to a depth of 7 in. will not bind satisfactorily under a 10-ton roller, what would you do?

Question 6.—(A) Under average conditions and with one good outfit, about how much macadam road can be resurfaced in one month?

(B) Explain the method of applying and watering screenings for a macadam road.

Question 7.—(A) Under average conditions, what is the cost of quarrying a cubic yard of stone?

(B) On fairly good roads, what is the cost of hauling a cubic yard of stone one mile?

(C) Under average conditions, what is the cost of moving a cubic yard of earth?

Question 8.—(A) How would you drain a road when constructed in one-half cut and one-half fill which winds around a hill side?

(B) How would you prevent bank from slipping?

(C) How would you bond the fill to the hill side?

Question 9.—A newly constructed macadam road has begun to pick up, what is the cause of this and how should same be remedied?

Question 10.—(A) Under average conditions, what is the cost per cubic yard for watering and rolling a macadam road.

(B) What is the approximate cost per mile for shaping road bed 14 ft. metal?

## STREET CLEANING COSTS AT SAVANNAH, GA.

Street cleaning at Savannah, Ga., ranges in cost from 20.4 ct. per 1,000 sq. yd. per cleaning for concrete to $1.249 per 1,000 sq. yd. for cobblestone. These figures are given by Mr. E. R. Conant, chief engineer of the city, in a paper presented at the recent convention of the American Society of Municipal Improvements. Extracts from Mr. Conant's paper follow:

The local conditions characteristic of Savannah, should be common in the average city from 70,000 to 125,000 population, lying below the heavy frost and snow line, where the contour of the streets are such that dry cleaning has to be resorted to. In Savannah all sewerage disposal is by gravity into the Savannah River. The general elevation of the city ranges from 10 to 30 ft. above high water, so that the sewer grade has to be flat, and by necessity dirt and refuse from the streets must be kept out of the sewers. Two or three of the principal down town streets are flushed three times a week.

White labor is entirely employed for street cleaning, but to a considerable extent the force is composed of a class which, on account of its physical condition, is unable to do what will be classed an ordinary day's work. Forty-eight per cent employed are over 50 years of age, and 9 per cent over 70 years of age. The organization of street cleaning consists of one superintendent at $110 per month, four foremen averaging $2.50 per day, and 70 laborers, including car and wagon drivers, at $1.75 per day.

Sheet asphalt streets are cleaned daily, except Sundays, with scrapers, and the scrapings placed in the gutters are promptly taken up with carts. With asphalt block and vitrified brick pavement, 40 per cent of the area is cleaned twice a week, 40 per cent three times a week, and 20 per cent twice a week. With granite block, 50 per cent is cleaned twice a week, 20 per cent three times a week, and 30 per cent once a week. Cobble-stone pavements are cleaned once in about 10 days. The method of cleaning asphalt block, vitrified brick, and to a large extent granite block, is by horse driven sweepers, preceded with sprinklers, all of this being done at night. Hand brooms and scrapers are used in collecting the sweeping in piles at the gutters, and these are taken up as formed, by carts and wagons during the day. Cobble-stone is hand cleaned with brooms.

The material collected from the streets amounts to approximately 20,000 cu. yd. per year. A large proportion of the sweepings are delivered to a local concern, which pays the city the nominal amount of $250 per annum for same. This party picks the coarser rubbish from the sweepings and mechanically grinds the refuse up and adds a certain percentage of cottonseed meal and potash and sells the resulting mixture as fertilizer, which is stated to be shipped to a large extent into Florida for truck farming.

Table I prepared from accurate data gives the cost of cleaning the paved streets of the city.

The cost given above covers and includes all labor involved, care of live stock, maintenance of equipment, purchase of all small implements and purchase of other apparatus, sweepers, carts, etc. It also includes the cost of stock which covers the replacement of necessary live stock. The city operates and maintains its own shop for repair work, horseshoeing, building of carts and wagons and making repairs to harness, etc., and the proper proportion of shop cost is included in the cost of work noted. It does not include interest on investment which, if added, would increase the cost not more than 1 per cent.

TABLE 1

| Class of pavement. | Average width in ft., total. | Condition of surface | Area in sq. yd. | Length, miles. | Cost of cleaning per year, including removal of debris. | Cost per mile per year. | Cost of cleaning per 1,000 sq. yd. per year. | Cost of cleaning 1,000 sq. yd., per cleaning. |
|---|---|---|---|---|---|---|---|---|
| Concrete | 30 | Good | 22,000 | 1.25 | $ 480 | $ 422 | $22.00 | $0.204 |
| Asphalt block | 35 | Good | 329,209 | 12.89 | 7,361 | 571 | 22.36 | 0.205 |
| Vitrified brick | 36 | Good* | 393,450 | 17.00 | 13,816 | 813 | 35.12 | 0.322 |
| Granite block | 31 | Fair | 116,962 | 5.95 | 4,800 | 807 | 41.04 | 0.415 |
| Cobble-stone | 28 | Rough | 76,478 | 4.13 | 4,968 | 1,203 | 64.96 | 1.249 |
| Sheet asphalt | 40 | Good | 141,319 | 5.04 | 12,226 | 2,426 | 86.52 | 0.277 |
| Total | .. | ....... | 1,079,418 | 46.26 | $43,650 | ...... | ...... | ...... |

*60 per cent good; 40 per cent rough.

## STATE HIGHWAY CONSTRUCTION IN MASSACHUSETTS IN 1915.

Nearly 50 per cent of the total mileage of roads completed in 1915 under the direction of the Massachusetts Highway Commission were of the waterbound macadam and gravel types. During the year a total of 181.92 miles of road was completed. Of this 60.07 miles were state highways, 44.97 miles were highways under the provisions of the "small town" act, 62.32 miles under the provisions of acts of 1910, and 14.56 miles under provisions of special acts. The mileages of the various types are as follows:

| | Miles. |
|---|---|
| Waterbound macadam | 23.26 |
| Gravel | 58.60 |
| Sand bound with oil and asphalt | 4.13 |
| Bituminous macadam* | 38.62 |
| Waterbound macadam with oil surface applied | 19.62 |
| Gravel with top surface bound with bituminous binder | 7.65 |
| Concrete | 5.34 |
| Gravel with oil surface applied | 16.61 |
| Warrenite | 1.30 |
| Granite block on concrete foundation | .09 |
| Dirt roads | 6.70 |

*Macadam with bituminous binder incorporated in the top course.

## PLACING CONCRETE BASE IN PAVEMENT CUTS.

Concrete mixers discharging directly into the cut enabled the city of Cincinnati, O., to speed up the work of replacing pavements torn up for putting in water mains.

The city at present is installing about 5 miles of high pressure water mains in the business district. This work has been somewhat difficult because of the heavy traffic. After the mains were laid and the trenches backfilled and tamped the mixers were used, as shown in accompanying illustration, to put in the concrete base for the pavement. By discharging directly into the trench a great deal of shoveling and wheel barrow hauling was saved. The mixer was moved along over the trench about 10 ft. each time. The materials were located nearby so that the loading wheelbarrows could run right up to the platform and empty directly into the mixer.

Concrete Mixer Discharging Directly Into Pavement Cut.

## CHANGES IN TRAFFIC ON MASSACHUSETTS HIGHWAYS.

That the traffic using the roads in Massachusetts is constantly increasing, but is changing much more rapidly than it is increasing, is shown by the accompanying table from the report of the Massachusetts Highway Commission for 1915. Table I gives a comparison of traffic in 1912 and in 1915 and Table II gives a comparison for 1909, 1912 and 1915. These figures were obtained by the Commission from censuses, taken in the years noted, at stations scattered throughout the states. In making a census the vehicles actually passing a station were counted for 14 hours a day (7 a. m. to 9 p. m.) for 7 consecutive days in August and again for 7 days in October.

TABLE I.—COMPARISON OF TRAFFIC IN 1912 AND IN 1915.

| | 1912 census (156 stations). | | | 1915 census (192½ stations). | | | |
|---|---|---|---|---|---|---|---|
| | Average total number per day. | Average per day per station. | Per cent of each class. | Average total number per day. | Average per day per station. | Per cent of each class. | Per cent increase or decrease over 1912. |
| Motors. | | | | | | | |
| Runabouts | 5,819.0 | 37.2 | 11 | 15,746 | 82 | 13.5 | +122 |
| Touring cars | 27,178.5 | 173.5 | 49 | 73,207 | 380 | 63.0 | +114 |
| Trucks | 1,800.0 | 11.5 | 3 | 7,260 | 38 | 6.0 | +230 |
| Total | 34,797.5 | 222.2 | 63 | 96,213 | 500 | 82.5 | +129 |
| Horse-drawn vehicles. | | | | | | | |
| 1 horse, light | 8,380.0 | 53.5 | 15 | 6,886 | 36 | 6.0 | — 33 |
| 1 horse, heavy | 7,458.0 | 47.6 | 11 | 8,412 | 44 | 7.0 | — 7 |
| 2 or more horses, light | 556.0 | 3.6 | 1 | 613 | 3 | ,5 | — 17 |
| 2 or more horses, heavy | 3,870.5 | 24.7 | 7 | 4,417 | 23 | 4.0 | — 7 |
| Total horse-drawn | 20,264.5 | 129.4 | 37 | 20,328 | 106 | 17.5 | — 18 |
| Total all kinds | ....... | 351.6 | .. | ...... | 606 | .... | + 72 |

TABLE II.—COMPARISON OF TRAFFIC IN 1909, IN 1912 AND IN 1915.

| | 1909—Average per station per day (238 stations). | 1912—Average per station per day (156 stations). | 1915—Average per station per day (192 stations). | Per cent increase in six years. |
|---|---|---|---|---|
| Motors. | | | | |
| Runabouts | 20.8 | 37.2 | 82 | +300 |
| Touring cars | 75.3 | 173.5 | 380 | +405 |
| Trucks | .... | 11.5 | 38 | ..... |
| Total | 96.1 | 222.2 | 500 | +420 |
| Horse-drawn vehicles. | | | | |
| 1 horse, light | 71.5 | 53.5 | 36 | — 35 |
| 1 horse, heavy | 49.3 | 47.6 | 44 | — 11 |
| 2 or more horses, light | 4.2 | 3.6 | 3 | — 28 |
| 2 or more horses, heavy | 26.0 | 24.7 | 23 | — 12 |
| Total horse-drawn | 151.0 | 129.4 | 106 | — 30 |
| Total all kinds | 247.1 | 351.6 | 606 | +145 |

## PERSONALS.

Hollie Ford has been elected county road engineer of Greaves County, Kentucky.

M. H. Mooney has been appointed county engineer of Grundy County, Missouri, with offices at Trenton, Mo. He succeeds W. E. Ralls, resigned.

William A. Duff, heretofore engineer of bridges of the Canadian Government Rys., Moncton, N. B., has been appointed assistant chief engineer.

W. B. Crawley, Abbeville, Ala., has been appointed county superintendent of roads for Houston County, Ala., succeeding the late W. E. McEachern.

Harry Bowers, has resigned his position as county road engineer of Ohio County, West Virginia, to become general superintendent of the Ball Engineering Co., Wheeling, W. Va.

William A. Austin, formerly chief engineer of the Lima Locomotive Corp., Lima, O., has formed a company called the Austin Engineering Associates. The firm will conduct a general consulting business, with offices in the McCormick Bldg., Chicago.

M. W. Serby has resigned his position with the New York State Highway Commission to become engineer for the Ochs Construction Co., general contractors, Allentown, Pa. This company has contracts for the erection of several new mills for the Bethlehem Steel Co.

J. M. Howe, of Houston, Tex., has been elected president of the Texas Association of the American Society of Civil Engineers. The other officers are R. C. Gowdy, of Fort Worth, first vice-president; R. J. Potts, of Waco, second vice-president; J. F. Witt, of Dallas, secretary-treasurer. These officers, with C. H. Chamberlin and J. B. Hawley, retiring and last retiring president, compose the Board of Directors.

Walter Higgins has been appointed assistant superintendent of the Victoria, Texas, Division of the Southern Pacific Ry. and will have direct charge of maintenance of way matters. Mr. Higgins was graduated from the civil engineering department of the Texas Agricultural and Mechanical College in 1907, and has been connected with the engineering department of the Santa Fe at Beaumont and the Sap at Yoakum.

Clark R. Mandigo, formerly assistant city engineer of Kansas City, Mo., is now a member of the engineering staff attached to the Kansas City office of the Portland Cement Association. Mr. Mandigo is a graduate of Harvard University and has had two years' experience on concrete construction for railroads and three years' experience as superintendent of construction for the U. S. War Department. For the past six years he has been assistant city engineer of Kansas City.

## OBITUARY.

Charles Wilcox Hotchkiss, chairman of the board of directors of the Virginian R. R. and president of the Chicago Tunnel Co., died Oct. 28 at Battle Creek, Mich., from organic heart disease. Mr. Hotchkiss was born in Unadilla Forks, N. Y., June 19, 1863. At the age of 20 years he entered the employ of the Pennsylvania R. R. as a rodman; in 1886 he became assistant engineer of the Michigan Central R. R.; in 1890 he was appointed division engineer in charge of the Chicago division of the Michigan Central; in 1896 he became chief engineer of the Chicago Junction R. R. and constructed the Chicago, Hammond & Western R. R.; in 1899 he became chief engineer of the Chicago Terminal Transfer Ry. and consulting engineer of the Michigan Central system; in 1900 he became president of the Indiana Harbor R. R. and constructed the Indiana Harbor Belt R. R. from Indiana Harbor around Chicago and the Chicago, Indiana & Southern R. R. from Chicago to Danville, Ill. After completing these roads, in 1905, he effected their consolidation with the New York Central system and became general manager of them; in 1912 he became president of the Chicago Tunnel Co. and the Automatic Telephone Co.; in 1913 he was called to New York to take the management of the H. H. Rogers properties and became chairman of the board of directors of the Virginian R. R., president of the Rail Joint Co. of America, president of the Staten Island Light & Power Co., president of the Staten Island R. R. and many other power, light and railroad companies.

## INDUSTRIAL NOTES.

A. M. Anderson, representing the Oshkosh Manufacturing Co., manufacturer of concrete mixers, portable saw rigs, pumps and back fillers, and The John F. Byers Machine Co., manufacturer of the "Byers" auto crane, hoisting engines, derricks, derrick fittings and material elevators, has moved from 1440 Monadnock Block, Chicago, to 605 South Dearborn St., where the above named equipment will be on display.

The Modern Iron Works, manufacturers of water works, municipal and gas supplies, Quincy, Ill., has organized what is to be known as a water works supply department, through which it proposes to furnish water works with anything they may require in the way of material and supplies (excepting cast iron pipe and water meters). The department will endeavor to keep in stock for shipment the day orders are received sufficient quantities of materials that are often required to meet an emergency.

Two additional licensees have been added to the family of the Dunn Wire-Cut Lug Brick Co., of Conneaut, O. These are the Streator Clay Manufacturing Co., Streator, Ill., which has recently completed a new plant with a daily capacity of 60,000 paving block; R. H. Green, President; James A. Green, Vice-President; and John Connelly, Secretary; also the Martinsville Brick Co., of Martinsville, Ind., with a daily productive capacity of 30,000; E. J. Poston, President; B. C. Poston, Vice-President; O. E. Sweet, Secretary.

Water Works and Hydraulics Monthly Issue
of
# Engineering and Contracting
Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., NOVEMBER 8, 1916. Number 19.

## A PROPOSED UNION OF THE TWO WATER WORKS SOCIETIES.

We have received a large number of letters commenting on the editorial in our last Water Works and Hydraulic Monthly issue, bearing a title similar to the above.

A considerable number of writers have requested us not to publish their letters, but in every instance except one the writers favored the consolidation of the New England and the American Water Works Association. Letters from other members of the two associations are published on following pages, and it is significant that there are very few that oppose a union of the two associations in some form. Even the few who prefer separate organizations raise objections that are by no means insuperable.

Mr. Heermans fears that a consolidation of the water works associations would eliminate the efficient work of the New England Association. This objection may be overcome by the formation of local water works "chapters" or "sections," each with its independent chairman and secretary.

Mr. Batchelder prefers the five meetings of the New England Association to the single annual meeting of the American Association. But there is nothing to prevent, and much to encourage, frequent meetings of the local sections of a national association. In fact the "4 State Sections"—Delaware, Southern New Jersey, Maryland, and Eastern Pennsylvania—of the American Water Works Association, holds a meeting next week, Nov. 15, at Wilmington. Similar meetings could of course be held by each section as frequently as desirable, and we are heartily in accord with Mr. Batchelder in believing that frequent meetings of local organizations are exceedingly useful.

Mr. Gwinn suggests that the consolidated water works association be called the International Water Works Society. Why not? The name should be broad and should be one that will not arouse jealousies.

Prof. Davis agrees with us that some combination of local associations is needed and that one of the objects of consolidation should be the elimination of politics from water works management.

Mr. Downes believes that a few topical papers should be presented at each meeting, so as to arouse the widest discussion and exchange of views. This plan is particularly effective in societies whose members are all interested in the same specialty, and it should work admirably in a water works society.

Mr. Burdick and Mr. Gillespie voice the need of a closer union of technical societies that have important interests in common. Speaking specifically of water works societies, their language implies belief in a general affiliation of all engineers and superintendents of engineering works. This broader phase of co-operative effort is discussed at some length in another editorial in this issue.

We ask our readers to give more than passing attention to the letters from the men above named and from many others, on the following pages. We shall welcome even the briefest expression of opinion from any reader engaged in water works design, construction or operation, for we are seeking to obtain a typical consensus of opinion of water works men on the wisdom of having one national water works society with local sections or chapters. In our December Water Works and Hydraulics monthly issue more letters on this subject will be published. We trust that some of them will offer outlines of the most effective form of a general society having local branches or sections.

## A GREAT FIELD FOR ENGINEER-PROMOTERS—IRRIGATION BY PUMPING.

The promotion of financially sound projects for improving land should be easier now than hitherto for three reasons: First, the high prices for farm produce assure large profits where farming is efficiently conducted near centers of consumption. Second, the rapidly growing supply of gold in America seeking investment makes it easier to sell attractive securities. Third, the "farmers' aid law" passed by the last Congress makes it easier to secure long-time loans on improved farm property.

Engineers who know, or even believe, themselves to be possessed of the ability to analyze and present costs and incomes relating to engineering projects in such a manner as to carry conviction, will do well to consider the opportunity to promote irrigation projects of moderate size in the "Great Plains" of America where pumping can be effectively applied.

In a 40-page pamphlet, Bulletin 141, entitled "Methods of Constructing Large Capacity Deep Wells," issued by the American Well Works, we find the following quotation from a recent report of H. B. Walker, Irrigation Engineer, Kansas State Agricultural College:

> It is my judgment that the western half of Kansas contains 2,500,000 to 3,000,000 acres of land where water may be encountered at depths of 60 ft. or less.

This "Bulletin 141" goes on to point out that the Great Plains contain vast areas of land where ample amounts of ground water are available to piece out an insufficient rainfall of about 20 in. per annum, extending all the way from the Dakotas to Texas. The bulletin goes into considerable detail in describing the recent, and really remarkable, development of a method of drilling wells of large diameter (30 in.) permitting the use of a 26-in. casing and a 24-in. "deep well turbine centrifugal pump." Such a well in the Great Plains ordinarily supplies enough water for 160 acres.

It is not our present object to review either the methods of driving 30-in. wells or the advantages resulting from the large size. We reserve that for our December Water Works and Hydraulic Monthly issue. What we now wish to emphasize is this fact:

This new method of securing water for irrigating the Great Plains economically is known to comparatively few capitalists. A civil engineer possessed of knowledge of what has been already accomplished, and gifted with moderate powers of persuasion, should be able to promote an irrigation project of small size to begin with and thence step to larger projects.

The editor has had enough experience with irrigation by pumping to have great confidence in the future development of this sort of irrigation. It can always be begun on a small scale, in which respect it differs from most gravity irrigation projects. Moreover—and this is of great importance—irrigation by pumping is applicable in states that are near the center of population, whereas gravity irrigation is applicable, for the most part, only in the more remote regions.

Engineers who are interested in the possibility of promoting irrigation projects—small or large—will do well not only to study the bulletin above quoted, but to secure some of the pamphlets on irrigation issued by the U. S. Department of Agriculture. The whole problem of economic irrigation is a fascinating one, and it offers a wonderful opportunity for the engineer who is also a promoter.

## THE INSUFFICIENCY OF THE RETURN ON THE INVESTMENT IN NEW YORK CITY'S WATER WORKS.

In his report for 1915, William Williams, Commissioner of Water Supply, says that the "estimated value" of New York City's present water supply system is $227,000,000 and that the new Catskill system will add more than $130,000,000 to the investment, making a total of fully $357,000,000.

The gross earnings for 1915 were about $13,000,000, and operating expenses, maintenance and taxes were about $4,500,000, leaving net earnings of $8,500,000, or less than 4 per cent on the $227,000,000 "value," or less than 2.5 per cent on the $357,000,000 even if the operating and maintenance expenses were not to increase, as they will, when the Catskill system is put into use.

What the depreciation on this vast investment will be probably nobody knows. Were it as low as 1 per cent, it would reduce the true net earnings to less than $5,000,000, or not quite 1.5 per cent on the investment!

Mr. Williams urges metering all services and the coincident abandonment of the "discriminatory frontage rate system." May we not add that any system of rates of charge will be discriminatory unless it yields at least a 4 per cent interest return on the entire investment?

To secure net earnings amounting to 4 per cent after setting aside a 1 per cent depreciation annuity would involve doubling the present revenue from operating the water works. Evidently the consumers of water in New York are not "footing the bill" by quite a margin.

The same sort of a condition exists in Philadelphia, and we doubt not that it also exists in every other large city in America—a condition of insufficient payment for water consumed.

## "THE GREATEST OBJECTION TO THE WATER METER."

Mayor Gaynor opposed universal metering in New York City on the ground that there would be a general cutting down on the amount of water used for bathing purposes. We are surprised to find the New York "Evening Sun" endorsing this argument:

> The greatest objection to the meter is the one advanced by Mayor Gaynor, however. The city administration which made the change without assuring itself that his apprehension was groundless would assume a grave responsibility.

How "grave" the responsibility really is can fortunately be established by the use of a little arithmetic. A bath tub of water ordinarily contains less than 50 gal. The weekly bath that the average person is presumed to take would therefore involve the use of 7 gal. a day. A change of 15 ct. per 1,000 gal. would make a bath cost three-quarters of a cent. Hence the price of a bath at a relatively high meter rate would certainly deter no person from taking it; but it should be remembered that metering does not necessarily increase the monthly bill for water. On the contrary, through the reduction of water waste effected by meters, the cost to the domestic consumers is made considerably less.

In a city using 200 gal. per capita per day, not 5 per cent of the water is used for bathing and washing purposes, whereas 50 per cent is wasted. Evidently, then, since most of the waste can be prevented by metering all services, the saving will be so great that several times as many baths as are now taken would cost no more than the present cost of water.

It would be well were mayors and city councilmen to accustom themselves to solving economic problems of this character by the use of numerical data which civil engineers can readily supply. We have had altogether too much of "the hot air method," typified by Mayor Gaynor's utterances, applied in the solution of economic questions. In a measure engineers are to blame for permitting such sophistry to go so often unchallenged.

## SHALL THERE BE A FEDERATION OF ALL CIVIL ENGINEERING SOCIETIES?

The number of societies of a civil engineering nature is large, and growing larger. Protests against further increment in the number are quite futile, for greater specialization inevitably begets new associations of men corresponding to the "specialties" that they represent. This is evolution, but it is not all of evolution, for as Herbert Spencer puts it: Evolution involves differentiation and concomitant integration.

Differentiation has been at work for many years in producing numerous engineering societies. We are about to experience an integration that will federate the many independent organizations of engineers into a powerful association, while at the same time each of the component societies will preserve most of its individuality. The threat of war has been instrumental in bringing all American engineers to a keener appreciation both of their power and of the dependence of the public upon them. The recently completed inventory of the nation's industrial resources available for war purposes—an inventory made by engineers—has focused public attention upon engineers. But, what is equally important, it has focused the engineer's attention upon himself, and has led him to study his relation to the nation. Each engineer now sees himself as one of a hundred thousand men, highly trained in the application of science, whose strength is partly unavailing because the public does not yet fully recognize the power of science. He asks himself, How am I to yield the service of which I am capable? And he is beginning to answer himself thus: First, I must join with all my fellow engineers in teaching the public what engineering is, and what it can become when adequately supported in its effort to benefit mankind. This sort of publicity is essential to more rapid industrial and social progress. It is not a work that isolated and relatively small bodies of engineers can effectively perform unaided. It demands the united effort of a great many men. A hundred thousand engineers tugging at the rope is none too many to pull the hundred million public into the light of a better knowledge.

The public is in a mood receptive to articles that set forth the claims of engineers. Witness the nation-wide interest in scientific management—a term coined by engineers, and a system exploited first by engineers. Witness the growing regard for the "city manager" vice the old-time mayor and council, and remember that the first "city manager" was an engineer, and nearly all "city managers" are engineers. Witness the syndicated writings in the daily press by such men as Dr. Frank Crane, who recently said:

> The man of the future will be the engineer.
>
> He is the man who can do things; and is better than the man who owns things.
>
> Some day little boys will read that the world once had millionaires and huge private wealth units, just as they will one day read and wonder that men once had kings.
>
> But the official who will forever be indispensable is the engineer.
>
> The time will come when the President of the United States will be chosen as the man who has the greatest talent and skill in organizing public works. There will be no more politics in his selection than there is now in choosing the master mechanic of a railway or factory.
>
> We need the engineer to arrange the transportation of people and goods from place to place without waste, without competition, without graft, looking only to the public good.
>
> We need the engineer to get meat, bread, and milk from farm to citizen without the present inefficient tangle of trusts and middlemen working at cross purposes.
>
> We need the engineer to turn the public enterprise toward building good roads and bridges, instead of enriching a few shrewd manipulators.
>
> We need the engineer to manage a city as economically and smoothly as if it were a manufacturing plant.
>
> We need the engineer to organize the farmers so that all can work together for each, and their products be marketed without being preyed upon at very step of the way from farm to household.

Wealth can be taken away from us. But the power to do things cannot be taken away.

The millionaires could go and not be missed. The engineers we cannot spare.

While Dr. Crane may be a bit blind to the real worth of the "millionaire" to society, it is undeniable that society has been very blind to the real worth of engineers. To operate on the cataract that darkens the public eye, Dr. Crane is evidently anxious, but he can not be sufficiently effective alone.

Engineers of broad vision, like William L. Saunders, President of the Ingersoll-Rand Drill Co., are seeking means to unite engineers in an effort "to bring the engineer forward to a position of influence in the affairs of government."

Much can be effected along this line by local engineering societies, but it is evident that a great deal more can be accomplished when engineers are organized nationally in such a manner that all engineering societies are federated.

As a preliminary step to such a general federation there should come a union of all societies of a civil engineering nature. We do not presume at this time to indicate the exact nature of the union. It seems likely that all existing societies that do not compete with one another should preserve their autonomy, at least in large measure.

Whatever the plan it should be one that will keep down the membership dues and place few restrictions upon the qualifications for membership in the federated society. Comment by our readers will be welcomed.

## HOW TO ELIMINATE POLITICIANS FROM WATERWORKS MANAGEMENT.

The construction and maintenance of streets, sewers and water works require engineering supervision if there is to be secured a high degree of efficiency. Even the dullest city councilman will concede that much to the civil engineer. It is but a step further along the same logical path to the generalization that a city water works should be managed by a man of technical rather than political experience.

Philadelphia's great "reform mayor," Blankenburg, was quick to appreciate this fact. He appointed a civil engineer, Carleton E. Davis, to be chief of the water works department in place of the politician who had held the office. Some years previously the business men of Philadelphia, led by John Wanamaker, had secured the appointment of an army engineer, Major Cassius E. Gillette, to the same position, but eventually the politicians ousted him, just as they had previously ousted John Trautwine, Jr.

In Philadelphia there has been an unceasing struggle on the part of the business men to secure a competent and honest administration of water department affairs, but the "spoils politicians" have invariably succeeded eventually in replacing a civil engineer head of the department by an incompetent politician. At last, however, there seems to be a fair chance of retaining an engineer in this position through more than one political administration.

In many a small city in America ignorant and incompetent men are in control of the water works. If even one agggressive civil engineer in such a city were to join its Chamber of Commerce and arouse the business men of the town to the need of engineering management of the water works, there is little doubt that a change could be effected. Although we urge united action on the part of engineers in public matters, it should be realized that individual action is also necessary. Moreover, individual action usually brings results quicker, although the results may not be imposing in their character or number.

In a small community one strong man who has a sound public policy to exploit will rapidly gain a following. Wait not, therefore, till all civil engineers are united in an effort to displace politicians from water works management, and the like, but "start something" yourself NOW.

## "IT MARKS THE ENTRANCE OF THE ENGINEER INTO GOVERNMENTAL AFFAIRS."—PRESIDENT WILSON.

The last Congress created a "council of national defense," and provided for an advisory commission to be associated with the council. In appointing the seven members of the advisory commission—or "efficiency board" as some newspapers term it—President Wilson gave out a statement, from which we quote below. The appointees are: Daniel Willard, president of the Baltimore & Ohio R. R.; Samuel Gompers, president of the American Federation of Labor; Dr. Franklin H. Martin, Chicago; Howard E. Coffin of Detroit; Bernard Baruch, New York; Dr. Hollis Godfrey, Philadelphia; Julius Rosenwald, Chicago.

The Council of National Defense has been created because the Congress has realized that the country is best prepared for war when thoroughly prepared for peace. From an economic point of view there is now very little difference between the machinery required for commercial efficiency and that required for military purposes. In both cases the whole industrial mechanism must be organized in the most effective way. Upon this conception of the national welfare the council is organized, in the words of the act, for "the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the nation." The organization of the council likewise opens up a new and direct channel of communication and co-operation between business and scientific men and all departments of the government, and it is hoped that it will, in addition, become a rallying point for civic bodies working for the national defense.

The council's chief functions are:

1. The co-ordination of all forms of transportation and the development of means of transportation to meet the military, industrial and commercial needs of the nation.

2. The extension of the industrial mobilization work of the Committee on Industrial Preparedness of the Naval Consulting Board. Complete information as to our present manufacturing and producing facilities adaptable to many-sided uses of modern warfare will be procured, analyzed and made use of.

One of the objects of the council will be to inform American manufacturers as to the part which they can and must play in national emergency. It is empowered to establish at once and maintain through subordinate bodies of specially qualified persons an auxiliary organization composed of men of the best creative and administrative capacity, capable of mobilizing to the utmost the resources of the country.

The personnel of the council's advisory members, appointed without regard to party, marks the entrance of the non-partisan engineer and professional man into American governmental affairs on a wider scale than ever before. It is responsive to the increased demand for and need of business organization in public matters and for the presence there of the best specialists in their respective fields. In the present instance the time of some of the members of the Advisory Board could not be purchased. They serve the government without remuneration, efficiency being their sole object and Americanism their only motive.

## EDITORIAL COMMENT.

The du Ponts, of powder fame, are said to have on their payroll 2,000 chemists, who, among other things, are conducting research work preparatory to giving Germany a "run of its money" in the production of dyes.

The City Managers' Association holds its annual convention Nov. 21 to 23 at Springfield, Mass. For the large city the "commission form of government" is showing increasing popularity. For the small city the "city manager plan" is evidently a preferable solution of the problem of executive control of municipal affairs. Portsmouth, Va., a city of 33,000 in 1910, has just called for applications for the position of city manager. It may not be long before the majority of small cities in America will do likewise.

There are in Philadelphia this year 610 little farms on vacant lots, upon which poor families have grown an average of $300 to the acre, according to Girard in the Philadelphia Ledger. He cites one farmer lad of 83, Jonathan Fly, who "coaxed at the rate of $900 out of an acre." Yet nearly all water works managers are so dead to the possibilities of selling water for irrigation that achievements like this occur in spite of their aid. Girard adds that these small farmers within the city limits frequently raise two or three crops in a season off the same plot.

## LETTERS TO THE EDITOR CONCERNING A UNION OF THE TWO WATERWORKS SOCIETIES.

Please accept congratulations on your article in the issue of Oct. 11 in regard to the amalgamation of the New England and the American Water Works Associations. In these days, when so much attention is given to efficiency, it is unfortunate that the two leading water works associations have not been combined. A combination would mean greater efficiency and an enlargement of influence.

With one large or parent water works association, and as many sections as may be necessary, more and better work could be done than at present and at a much less cost.

As there would be no objections to the continuation of either society, the writer would suggest that a new one be formed to take over the old ones, under the name of the International Water Works Society.

Dow R. Gwinn,
President and Manager Terre Haute Water Works Co.
Terre Haute, Ind.

For many years I have been a member of both societies. "Old jealousies," if they exist, are not of general interest to the profession and should not be permitted to interfere with the consolidation of the two societies into one strong organization for the benefit of all concerned.

Clarence W. Hubbell,
Consulting Engineer.
Detroit, Mich.

I have read with interest your article on the consolidation of the two water works associations. While there might be many advantages in that action, there would be some considerable disadvantages.

The New England Waterworks Association is fortunate in being comparatively a compact association. The members have meetings five times during the year in addition to a June outing and a convention in September. To my mind the advantage of those meetings is superior to that of an association which meets only in annual conventions.

I also believe that one association would be so large and widely scattered in its membership as to be unwieldy.

Geo. W. Batchelder,
Water Commissioner.
Worcester, Mass.

I am not intimately enough connected with the guiding powers of either organization to speak first hand of the petty jealousies said to exist, but it devolves from the very rudiments of human nature, which are, after all, but little effected by any amount of "culture," that such jealousies do exist. It is, therefore, probably useless to talk of either organization absorbing the other, however desirable the result might be.

The only hope, I believe, lies in the appointment of a commission from each association to form a new organization with a distinctive name, of which organization all members of the present societies shall automatically become members. It being agreed that on formal organization of the new society in general convention the old organizations shall automatically cease to exist.

There is a feature of the economic waste not mentioned in either of your editorials, and that is the duplication of papers on the same subject. The aim of these, as of all other societies, seems to be to bring to the convention the greatest possible number of papers, with the result that few of them are half read and none of them are allotted adequate time for discussion. The discussion elicited by a paper constitutes its real value. Yet people who have been specially invited to prepare a paper, or to discuss one, are repeatedly greeted with a snapping of watches and an atmosphere of disquiet and hurry which is, to say the least, a poor reward for the work and time given to the preparation of such papers. Much good discussion could undoubtedly be brought out from "the men on the jobs" who have not been specially invited to talk, were it not for the fact that they feel utterly squelched and shoved off the board by the constant sense of being hurried on to the next number on the program.

As stated this is a failing not peculiar to the two societies under discussion, but one inherent to all such organizations, and one, the elimination of which, should be given the most profound consideration in any scheme for a united organization.

I believe that a little real thought given to this subject might result in the grouping of discussions about a few topical papers (say not more than one to a half day session) in place of the wild efforts to secure enormous numbers of papers with which to fill the program.

John R. Downes,
President New Jersey Sewage Works Association.
Plainfield, N. J.

As an old member of both water works associations, I am opposed to the consolidation proposed in your recent editorial. As a practical water works operator, of small plants. I have obtained very valuable information from the meetings and the printed proceedings of these associations.

The real value of any association results from the activity and work of its members. This work devolves largely upon the officers, who use the initiative in securing the co-operation of leading associates and eminent men in the profession.

The New England Water Works Association has performed unique service in its quarterly meetings, bringing forth articles and data and reports on development work, the result alone of the activity of its officials. Will you now by consolidation of this efficient organization with the American Water Works Association eliminate the good work of the former? Each of these organizations has its own field and does a good work for its members. By all means do not break up the activity or the initiative of either by consolidation. They are rival organizations, each a stimulus for the other. Let the good work go on, we are satisfied.

Harry C. Heermans,
President and Manager Hoquiam Water Co.
Hoquiam, Wash.

Permit me to commend in the strongest terms your recent editorial agitating amalgamation of the two large water works associations in this country. As a member of both I can see no real advantage in the separate existence of the two. Local pride and jealous considerations are no doubt the strongest factors which keep them apart.

I believe this to be an extremely far-reaching movement which will ultimately eliminate a vast number of locally existing engineers' societies as such and result in their absorption by a national association closely allied in specialistic aim. Such societies as now exist will doubtless become branches of a parent association.

In order to reduce the size of the printed volumes of the national society, only the best papers presented locally should be there printed, a competent board of review to pass on the fitness of articles for publication.

I trust that the movement may succeed.

C. G. Gillespie,
Director Bureau of Sanitary Engineering, California State Board of Health.
Berkeley, Cal.

As you are probably aware, I am now a member of the American Water Works Association, consequently it is possible that an expression coming from myself would be considered one-sided. However, I agree with the sentiment expressed in your editorial.

I never have been able to see any reason for two associations and have often wondered what real difficulty was in the way of efforts which I know have been made to combine the two associations.

In addition to the reasons which you have yourself given for combination of these two organizations it appears to me that the policy on a number of questions in which there seems to have been disagreement between the two associations could have been settled much easier if all the members belonged to one association; and the prestige of such a large body of trained men behind questions of vital interest could certainly be made a great power for good not alone for water works men, but for the water consuming public in general.

Chas. F. Barrett,
Superintendent of Waterworks.
Salt Lake City, Utah.

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You have my most hearty support in your efforts to bring about the consolidation of these two societies. I hope the day is not far distant when all the water works organizations in the country will be branches of the American Water Works Association. However, if it would be necessary to organize under another name, I would be willing that that should be done.

I would be very glad indeed, to see the consolidation of our engineering societies, for there are many matters very important to engineers that are engineering matters rather than matters of civil engineering, electrical engineering, mechanical engineering, or the various other branches of the profession. If consolidation could be brought about, it would greatly increase the value of the papers and the discussion, for all the specialties of engineering overlap to a certain extent.

The efforts of your paper to bring about the consolidation of the water works association or the engineering societies will have my most hearty support and the support of many of my friends.

Chas. B. Burdick,
Consulting Engineer.
Chicago, Ill.

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I was the first junior editor of the Journal of the New England Association and supervised the printing of the first few numbers. It is evident therefore that my experience, my interest and my sympathies are with the New England Association, although it is something like 30 years since I ceased to have any active connection with it.

It seems to me that there are certain things, and the annual exhibition is of course one of them, which can be done much better through one national association that it is now done by two separate organizations. I am quite ready to believe also that a movement to divorce water works management from politics could be more efficiently handled through one national association and a little time for careful consideration will undoubtedly bring out other ends, which can be best attained through centralized effort.

On the other hand, as one of our ex-presidents is fond of saying, I am quite sure that this country with its magnificent distances is too widespread to make it possible for any one association to do all that water works men can do for each other by co-operation and frequent personal contact. If there is to be a national association there should be local chapters and one of those chapters would surely cover the New England field. During the winter months, monthly meeting are well worth while and obviously monthly meetings of a national association would be impracticable. The foregoing ideas might with a little time for thought be worked out in detail, but strong as my sentimental interest is in water works engineering, my practical interest ended so long ago that I am hardly competent, even if I had the time, to take part in that careful consideration of details which will be necessary if the proposed consolidation is to be made effective.

Wm. R. Billings.
New York City.

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The proposed consolidation of the New England Water Works Association and the American Water Works Association discussed in your editorial of Oct. 11 should receive the thoughtful consideration of the water works fraternity.

There is undoubtedly much duplication of effort and loss of efficiency due to the lack of co-operation between the associations. The holding of a single convention of water works men and the publication of a single journal are greatly to be desired and would doubtless result in increased interest and enlarged membership in the water works societies. The ridding of water works management of political interference and other matters of similar nature can also best be done by a strong national society. Some form of co-operation is therefore desirable.

It is the opinion of the writer, however, that a merging of the two associations into one would result in the slackening of effort of many of the progressive spirits in one or the other of the two organizations. The identity of the New England Water Works Association should therefore be maintained as a distinct organization and the establishment of water works societies encouraged in other sections of the country where the climatic, economic and political conditions are greatly different from those in New England.

Some form of organization could be worked out which would allow the American Water Works Association, the New England Water Works Association, the Illnois Water Supply Association (which is now affiliated with the American Water Works Association) and other societies to co-operate along lines where interests are mutual and where economy of effort would result without stifling the pride in local associations which is productive of much efficient work.

Geo. Jacob Davis, Jr.,
Dean, College of Engineering, University of Alabama.
University P. O., Alabama.

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I have been a member of the New England Water Works Association for many years, and while being unable to attend most of its annual convention junkets, I have tried to attend as many of its monthly winter meetings in Boston as possible, feeling that I cannot afford to miss the profit gained by an interchange of practical experiences with other water works officials with whom I rub elbows at these meetings.

My opinion, derived by long observation, is that a large consolidation does not benefit the many smaller officials (to use this term) so much as it furnishes opportunity for the larger officials and technical men to exploit and advertise themselves over the heads of the many practical water works men who need more the friendly interchange of experiences and how each of them have overcome everyday practical difficulties arising in their work.

In these days the term "efficiency" is a much abused one, and is liable to run to extremes if in the craze to realize it the effect should be to destroy or minimize the initiative and individuality of the worker, upon whom the final result always depends.

On page 312 of your magazine (the page following your editorial) the meat of this whole movement for consolidation is expressed in the heading of the first article, entitled "Why Have Two Water Works Shows"? and the term "shows" is therein used in several places. The whole movement appears to me to be only another attempt of the associate members (whom I esteem very highly) at economizing of expense in making exhibits of water works appliances at conventions. This is a proper and laudable effort to make on their part and from their point of view.

But I submit that the majority of the practical water works men who attend meetings and conventions do so for the principal reason that they can meet each other, listen to instructive papers and exchange experiences, as before noted, to the great profit and broadening of view in the grasp of their official duties.

I am not attempting to decry in the least the great advantages gained also in seeing the exhibits of water works machinery and supplies, but if it came to the final question of doing without the one or the other, then the latter would unquestionably affect such gatherings the least.

As for the supposed existence of "old jealousies" between the two associations, as expressed in your editorial, I can say that from my experience and observation I believe very little in such "jealousies" existing to the extent that some would have us think.

This country of ours is too large to have such a consolidating of associations and expect the attendance at meetings of those officials for whom such associations were originally created. Rather would I favor more and smaller gatherings, with the resulting increase of practical interest by the rank and file of water works men, and a continued live interest and profit from same, even if the aggregate expense might be considered greater than otherwise.

I heartily agree with your statements regarding the desirability of eliminating "politics" from the management of municipal water works (or any other municipally owned utility), and believe that much might be accomplished in this direction by a federation of effort along this line, not only by water works officials, but by officials of other public utilities as well. I hope to see this attempted more and more.

A. P. Hathaway,
Water Registrar.

Springfield, Mass.

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I am a new man on the job and also a new member of the New England Water Works Association, so my opinion can only be based upon general principles.

Personal contact with many of the officers and the rank and file of the New England Association members would make it hard indeed for me to believe that jealousy would have any part in the meditation upon the question of consolidation or the decision. I favor any policy which makes toward better education for us all, and the larger the school the more teachers.

H. E. Bryant,
Superintendent Water Works.

Kingston, Mass.

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We have read your editorial relative to the merging of the New England and the American Water Works Associations, and will say that we believe that much more benefit would be derived from an educational standpoint by having all of the water works associations of the country merged with the American Water Works Association as a national institution. We question, however, the advisability of advocating the merger for the purpose of driving politics out of water works management. We are inclined to believe that the merger would fail if this movement was advocated as a reason for the merger.

Scott B. McGowan, Secretary.
The John H. McGowan Co.,

Cincinnati, O.

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It is evident from the present discussion of this subject that water works men recognize the futility of maintaining two separate associations. They have for their purpose the same object in view. There is, even now, a get-together movement by committees whenever vital subjects come before the two organizations to do away with absolutely indefensible dual standards. A consolidation would concentrate the efforts of all water works men and clear the way for real progress. This will effect an organization which would be recognized as one of the specialized bodies of the country.

J. A. Jensen,
Supervisor Water Works Department.

Minneapolis, Minn.

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I read with greatest interest your editorial in the Oct. 11 number of Engineering and Contracting with reference to the advantages of coalition of the American and New England Water Works Associations. I most heartily agree with the sentiments which you therein expressed.

Duplication of organization is a calamity in this country. For instance, we have two great national highway engineering and road building organizations and many local organizations or similar scope where only one main organization, perhaps with local chapters, should exist. The same situation exists with respect to our water works associations. There should be but one water works association and all local associations should simply become chapters, so-called, in the parent organization.

A tremendous waste of energy and money is shown in the attempt of local engineering societies to maintain proceedings independently. Much of the material published in such proceedings is of but small merit. A combination of all of the local engineering societies in this country, at any rate with respect to the publication of papers, so that but one "Journal" would be published, would, in the opinion of the writer, represent a tremendous advance.

I sincerely hope that the efforts which you and several others are making will shortly bring about a coalition between the American and New England Water Works Associations.

Charles Gilman Hyde,
Professor of Sanitary Engineering, University of California.

Berkeley, Cal.

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After reading the Water Works and Hydraulic monthly issue, on the consolidation of the various water works associations, the question appeals to me as one broad in scope and of serious importance to water works men generally.

Many have felt the societies are too numerous, especially among the water works men. The subdivisions of the various societies do not lead to the fulfillment of the object for which the various associations were incorporated. Personally, I have always been an advocate of combining all the water works interests into one, centralizing the same in one of the large cities, similar to the American Society of Civil, Mechanical and Electrical Engineers. All data could be collated there, bearing on every important question relating to water works, which today must be carried forward by each company interested in a particular subject. A combination of the water works association, under one general head, would also help develop the water works superintendent and engineer.

Today the management of water works involves many intricate problems, calling for expert knowledge along many lines, and very often, under present conditions, advice is sought for by those in power, who do not comprehend the problem or the solution therefor. The water works association should ultimately direct a course of education for the coming water works superintendents and engineers, for these positions today require trained minds in mechanical knowledge, executive ability, and a fund of human instinct akin to second nature; all of which is not taught in the general college course.

By all means consolidate all the water works associations under one general head if the majority decides, and the future will reap the reward.

A. W. MacCallum,
Consulting Engineer.

Philadelphia, Pa.

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I have read with interest the editorial in the last Waterworks and Hydraulic Monthly issue of Engineering and Contracting urging the consolidation of the American and New England Water Works Associations and desire to compliment you on your stand in the matter. As a member of both associations I can see no valid reason why they should not be united. It would certainly be to the advantage of the public generally and of waterworks engineers particularly. They might even get some "standard" specifications that were really standard.

A. Lincoln Fellows,
Consulting Engineer.

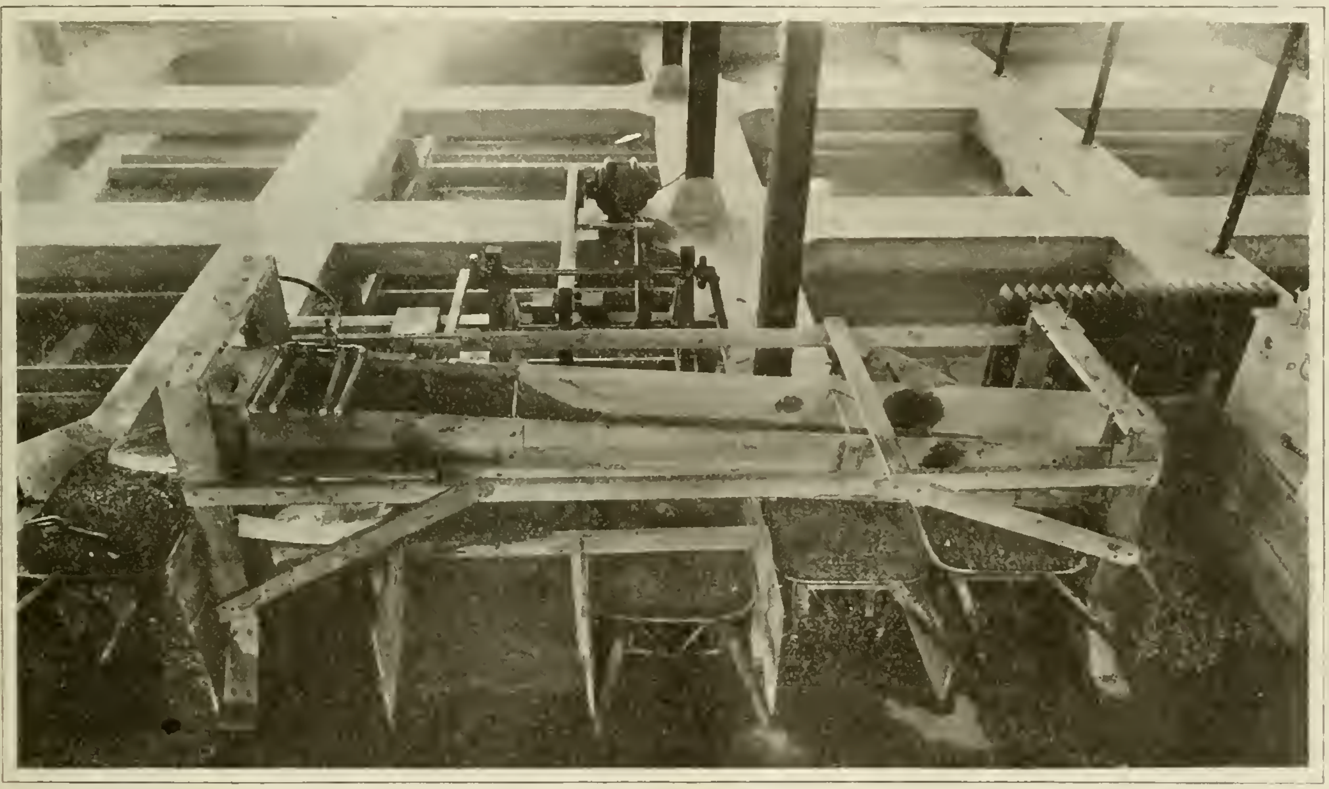
Denver, Colo.

## GRAVEL GRADING MACHINE USED AT GRAND RAPIDS, MICH., FILTER PLANT.

During the winter of 1914-15 the officials in charge of the filter plant of Grand Rapids, Mich., decided to remove the screens separating the filter gravel from the sand and to increase the thickness of the gravel layers to a point where they would be stable against the upward force of the wash water without the aid of the screens.

This increased the bulk of gravel to be handled in subsequent overhauling of the filters three or four fold. Formerly it was necessary to spread the gravel out to dry on the filter gallery floor and later work it by hand through a series of screens 2 ft. square sliding on a set of saw horses fastened parallel to one another which obviously necessitated working over the entire pile of gravel once for each grade of gravel separated. With these new conditions as to volume of gravel some other method had to be devised.

This was met by the machine shown in the accompanying illustration. It was constructed by the men on the plant regularly employed at a total cost of $37 exclusive of labor and cost of extra wiring for the spare motor used to operate it.



Gravel Grading Machine Used at Grand Rapids Filter Plant.

The machine was made entirely of wood, all fastenings being made with bolts. It is run at a rate of about 125 to 135 r.p.m., consuming not to exceed 3 HP.

The mixture of sand and gravel is shoveled in at one end where it first passes under the washing rig consisting of four 1-in. pipes perforated with small holes, the whole being supplied from a hose attachment which provided the proper flexibility while the machine was in motion. This thoroughly washed the sand from the gravel eliminating the need for drying as formerly. As the gravel passed on down the screen it was found that usually the first 6 in. of each screen did the work of separating its particular size.

Five men are required to operate and keep the machine going at full speed, the gravel being taken from a filter washed, graded and piled in piles ready to go back in two days. It was figured that the time saved by this machine was from 75 to 85 per cent of the time that would have been required by the old method. When not in use the machine is knocked down and stored. Walter A. Sperry is Chief Chemist of the Filter Plant. L. D. Cutcheon is Secretary and General Manager of the Board of Public Works.

## AN EFFECTIVE METHOD FOR HANDLING BAD WATER COMPLAINTS.

The Des Moines Water Co. of Des Moines, Ia., put into operation some months ago a plan for handling bad water complaints that has proved so effective as to justify its adoption as a permanent method of dealing with this subject. This plan was described by Mr. E. T. Kirkpatrick, Chemist and Bacteriologist of the company, in a paper presented at the recent joint meeting of the Iowa and Illinois sections of the American Water Works Association. Extracts from Mr. Kirkpatrick's paper follow:

When a bad water complaint comes in, as it is a question of the sanitary condition of the water, it is referred to the laboratory. Here it is given a serial number and filed in the "complaint book," together with the date, name and address and cause for the complaint, and the consumer is told that an early call will be made for the purpose of inspecting the water.

This serial number is then transferred to a map of the company's distribution system at the location of the complaint. This map, together with the complaint numbers, makes an excellent record of the complaints. It shows graphically the location from which the complaints are coming and makes a simple method for the routing of the trips on which the subsequent calls are made.

The call is then made upon the complaining consumer and the water examined. With the Des Moines water the majority of the complaints arise from dissolved iron. If there is only a slight amount of this iron present the usual complaint is that the water has a strange taste. In this case it is explained to the consumer that this taste is not due to the presence of disease-producing organisms or anything that would cause physical disorder, but is merely the taste of a small amount of iron which is considered beneficial to the human system. This explanation is ordinarily taken at its face value by the consumer and the main is not blown off.

If, however, there is a greater amount of iron present the usual complaint is that the water is unfit for laundry purposes. If on examination this statement is found to be true the main is of course blown off. Sometimes on such occasions it is found that there is some sediment present. When this is the case this content is estimated by means of the Whipple sediment test. This consists in forcing a measured amount of the water, usually a quart, through a white cotton felt disc which retains upon its surface the sediment contained in the water. This disc is taken to the laboratory, dried and mounted in a book, making a graphic record of this condition of the water.

Another class of complaint comes from the citizen whose family is about to be taken from him by typhoid fever resulting from the use of the grossly polluted city water. True they do not have the fever at the time of the complaint, but the water has an odor and a taste which the complainant believes to have come from some pollution and is likely to contain the germs of typhoid fever. In dealing with such complaints an attempt is made to show the parties that they cannot rely absolutely upon the means that they have at hand to determine whether or not a water is fit to use. The representative of the company explains if he can the cause for the unfamiliar odor and its perfect harmlessness. He also explains some thing of the purification system and endeavors to show the impossibility of typhoid being present. A sample is then taken for bacteriological examination. When this examination is finished the first call is followed up with a second showing the results of the examination and what they signify, and the complaint is not dropped until the consumer is convinced that the water is pure. Almost invariably the consumer appreciates the efforts which the department has made in the investigation of his complaint and is willing to accept its statements concerning the purity of the water.

Before concluding any of these calls the representative tries to leave the impression that the company is not displeased to have received the complaint, but is interested at all times in learning from its patrons the condition of its water. The experience so far has been that the public has responded to this attitude and is more friendly towards the company. Chronic kickers who have been accustomed to calling up every week or so to make some new criticism concerning the water seem to have lost their interest in their self-appointed tasks since they have been encouraged to continue in their good work. Those who have been truly frightened concerning the condition of the water have upon learning the true situation, gained more confidence in the purity of the water.

## EFFECT OF WIND VELOCITY ON WAVE HEIGHTS.

Some observations were made during the year 1915 on the Belle Fourche Reservoir of the U. S. Reclamation Service to determine the height of waves under various wind velocities. A wave gage was erected well out in the water and a recording anemometer was installed. The height of waves from crest to trough was observed during various periods of high wind velocity, the results as reported in the November Reclamation Record by Project Manager B. E. Hayden being as follows:

| Date. | Wind velocity, miles per hour. | Wave height, feet. |
|---|---|---|
| Aug. 28 | 35 | 2.0 |
| Sept. 8 | 40 | 2.5 |
| July 4 | 44 | 2.5 |
| May 16 | 48 | 3.5 |
| Oct. 7 | 50 | 3.5 |
| June 12 | 56 | 4.0 |
| Oct. 24 | 75 | 5.0 |

The fetch of the wind was approximately 5 miles for all observations, and the depth of water during the entire period varied but 3 ft., the mean depth at the gage being approximately 10 ft.

Mr. D. C. Henry, in an article in the Engineering News of June 29, 1916, has derived a formula from these observations, as follows:

> In plotting the heights of waves as abscissas with the wind velocities or ordinates it is found that a straight line fits all points fairly closely. The formula of this line is
>
> $$H = 0.075 \ (V - 8.5),$$
>
> V being the velocity of the wind in miles per hour and H the total height of the wave from crest to trough in feet. With a wind of 8.5 miles, the wave height is practically zero.

Experiments will be made on other Reclamation Service reservoirs to test the general applicability of this formula for a fetch of 5 miles and to determine the effect of variable fetch.

## BACKFILLING TRENCHES WITH A ROAD GRADER.

Contributed by William E. Voorhees.

Mr. P. S. duPont of Wilmington, Del., recently installed a complete water works system on his large estate at Longwood, Chester County, Pennsylvania. This system included about 2 miles of 6-in. mains laid in trenches varying in depth from 3 ft. to 10 ft. The trenches were dug with a Parsons trench-digging machine. While it had been possible to lease a machine for digging the trenches there was no equipment in sight for backfilling that could be secured at a reasonable price. To fill the trenches by hand meant the expenditure of approximately $2,000, and, owing to the scarcity of labor, much inconvenience must have necessarily resulted on account of the long time required to complete the work.

After looking into the situation carefully it was decided to attempt to fill the trenches by means of a road grader pulled by a gas tractor. In the work of excavating the trenches the earth had been deposited from 4 to 5 ft. from the edge of the trench. In some cases the pile of earth was 5 to 6 ft. wide at its base and fully 5 ft. in height.

Road Grader Hauled by Tractor Backfilling Trench.

The road grader used was of the ordinary standard reversible type. The rear axle was made quite short so that the machine could travel between the windrow of dirt and the edge of the trench. The machine was equipped with a scraper bar 8 ft. in length. On account of its length it was possible to set the bar at an angle sufficiently sharp to enable the dirt to flow freely from one end to the other. The machine was fitted with an offset pole and steering device so that a man sitting o the front seat could steer the machine away from th edge of the trench and close to the bank of dirt.

The tractor used in drawing the machine was of th caterpillar type. In operation the blade of the machin was set so that the front end engaged well into the ban of loose earth. This brought the rear end of the blad close to the edge of the trench, so that when the machin was put in motion the earth flowed from the front en of the blade back into the trench. In cases where th windrow of earth was abnormally high it was necessar to cut the tractor loose from the machine and run it ove the peak of the pile so as to scatter and beat down th earth and thus enable the road machine to handle it t better advantage.

The illustration shows clearly the method of handlin the machine in delivering the loose earth into the trenc The scraper bar of the machine was reversible and it wa possible, therefore, to deliver dirt to the trench no ma ter which direction the machine was running. For th reason no time was lost. It was necessary, of course, make several rounds before all the dirt could be deli ered to the trench, but when the work was finished th trench was filled and the ground adjoining it was cle of loose earth.

While no exact cost figures were kept, judging from the time required to fill the 2 miles of trench—about a week—it is safe to assume that the work was done for less than 20 per cent of what it would have cost by hand labor. The road machine was purchased especially for this work, but it was in first-class shape at the conclusion of the job and can be used to good advantage for other work in the future. The tractor was used regularly for farm work, but was pressed into service for this particular work because it was better adapted for pulling a road machine than any other power that could be secured.

## RESULTS AND CONCLUSIONS FROM A YEAR'S OPERATION OF THE ACTIVATED SLUDGE SEWAGE TREATMENT PLANT OF MILWAUKEE.

The activated sludge sewage treatment plant* of Milwaukee, Wis., was placed in operation on Jan. 22, 1916, and has been in almost continuous service since that date. The results obtained have been so satisfactory that the process has been adopted by the Sewage Commission of the city and plans for a plant to treat 100,000,000 gal. of sewage per day are now being prepared. In a paper presented at the recent convention of the American Society of Municipal Improvements, Mr. T. Chalkley Hatton, Chief Engineer of the Commission, gives the results obtained from the year's experience with the workable size unit. The major portion of Mr. Hatton's paper follows:

The plant has been operated at rates varying from 650,000 gal. to 2,000,000 gal. per day, with a volume of sludge in the aerating tanks varying from 10 per cent to 30 per cent, and with a variation in the aerating capacity. Vertical and horizontal flow sedimentation at various velocities has also been tried. In fact the plant has been put through many stunts to determine both positive and negative results.

Experiments and observations have been made for several months to determine the volume of sludge collected and a satisfactory method of de-watering, drying and reducing the sludge to fertilizer basis, and, while these determinations are not final by any means, as experiments are still being conducted, they have progressed far enough to warrant Mr. Hatton in drawing approximate conclusions.

### Securing Activated Sludge.

When the continuous flow tanks were first put in operation the work indicated it would require from 30 to 35 days of continuous aeration to secure well activated sludge. In a tank put in operation on July 29, and through which was treated 50,000 gal. per day continuously, good activated sludge was secured in about ten days, at the end of which time the volume of sewage treated was increased to 75,000 gal.

The general character of well activated sludge can be easily determined by the eye. It has a golden brown color flocculent and settles very rapidly in a bottle, forming larger flock as it settles.

It has been the practice to measure the amount of activated sludge combined with the raw liquor in the aerating tanks in terms of percentage. This is determined by allowing the mixture to settle one-half hour in a graduated glass cylinder. The half-hour period was chosen because in well activated sludge 77 per cent settles in 30 minutes in quiescent liquor, 82 per cent in one hour, 84 per cent in two hours, and 86 per cent in three hours.

In order to maintain 25 per cent of activated sludge in the aerating tanks it has been found necessary to return from the sedimentation tank from 40 to 50 per cent of the volume of raw liquor being treated, because the liquor drawn from the sedimentation tank is only about one-half sludge. This, of course, means if four hours detention period is desired in the aerating tank for the raw liquor the tank must be proportioned for a six hours' detention or 50 per cent increase.

This might be overcome by providing secondary sedimentation tanks in which the sludge from preliminary tanks would be settled for one hour, the supernatant liquor run off and the thick settled sludge returned to the aeration tank. By this method the moisture content in the settled sludge in the preliminary sedimentation tank can be reduced from 99 per cent to about 96 per cent. This method, however, would increase the area and tankage without decreasing the air, and would add to the operations of the process.

### Aeration.

The air used for aeration is secured by operating a Connersville positive blower of the Boston type, capable of compressing 2,400 cu. ft. of free air per minute to 5 lb. pressure. The compressed air passes through a filter built into the main pipe and filled with excelsior. From the indications Mr. Hatton believes that much better results can be obtained by filling this filter with absorbent cotton, although considerable oil and dust have been intercepted by the excelsior.

The air used is measured by recording air-meters furnished by the General Electric Co., one meter measuring the air used for the aerating tanks and another that used for pumping sludge from the sedimentation tank. The diffusers consist of filtros plates 12 in. square and 1½ in. thick, furnished by the General Filtration Co., of Rochester, N. Y. There is 1 sq. ft. of diffuser to 8.5 sq. ft. of tank surface.

Before the filtros plates were set each was tested for porosity under a 2-in. water pressure, and the variation was from 1.85 cu. ft. of air per minute per square foot of plate surface to 5.85 cu. ft. per minute. This variation has resulted in one tank receiving more air than its neighbor and the liquor passing through such tank picks up more dissolved oxygen.

This is an objection to the use of filtros plates which Mr. Hatton thinks has been largely overcome since these plates were purchased, the manufacturers exercising more care in the selection of the materials and in testing the finished plates before shipment. Another objection to this type of plate, which is more difficult to overcome, is the frictional loss. In order to saturate the plate when passing the air through under 5 lb. pressure, there is a frictional loss of ¾ lb., and for every cubic foot of air per minute passed through the plate at this pressure there is an additional loss of ¼ lb.

Experiments have been made with a wooden block diffuser with very promising results. The block is cut from basswood across grain and is about ½ in. thick, 12 in. long and 3 in. wide. Four blocks are set side-by-side in a casting about 12½ in. square. The experiments indicate so far that the frictional loss when 5 cu. ft. of air per minute under 5 lb. pressure are passing through plate is about ½ lb. The air is broken up in much smaller bubbles and is better diffused throughout the surface of the plate. If the wood proves satisfactory it has the advantage of being cheaper, obtainable in all markets and easily removed and replaced without injuring the frame, as it is held in place by the pressure due to the swelling. It is quite probable that less air will be required with the wooden diffusers because of the much smaller bubble, which will result in greater saturation. Experiments are now being conducted to try this out.

Uniform diffusion over the entire area of an aerating tank would, of course, be the ideal condition, but in a large plant this is impossible to maintain, and Mr. Hatton believes that its importance is not sufficient to warrant large expenditures.

The aerating tank which has given the best results in Milwaukee has the following proportions: 1 sq. ft. of diffusing surface to 5.5 sq. ft. of tank surface. Average depth of liquor, 9 ft.; 275 gal. of raw liquor treated per day per square foot of surface. If the tank was 14.5 ft. deep the amount of liquor treated could be increased 50 per cent. One cubic foot of aerating tank capacity treats 29 gal. of sewage per day. If wood diffusers are used the indications are that better nitrification with less air could be secured by increasing diffuser area about 35 per cent, thus reducing volume of air passing through each square foot of diffuser. This very materially decreases size of bubble and increases saturation. The above proportions provide for the activated sludge returned from the sedimentation tank.

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*A description of this plant was printed in the Oct. 27, 1915, issue of Engineering and Contracting.

A combined sewage at times carries large quantities of mineral and other heavy inorganic matter to the disposal plant. This matter settles upon the surface of the diffusers and interferes with their efficiency. It is, therefore, quite important that a satisfactory grit chamber form a part of every disposal plant of this character treating combined sewage.

Considerable thought has been given to the question of fine-screening the sewage. Mr. Hatton is of the opinion that this is unnecessary as it adds to the expense and diminishes the value, as a fertilizer, of the sludge.

### Effect of Low Temperatures.

The Milwaukee plant was put in operation about Jan. 22, 1916, and by Feb. 1 was in continuous operation. During February, March and April the temperature of the sewage varied from 34° F. to 50° F. and the outside air from —14° F. to +69° F. During this time the plant produced an effluent stable for 108 hours, 98 per cent removal of suspended matters, 97 per cent removal of bacteria at 37° C. and 83 per cent oxygen consumed, but required about 50 per cent more air than when the temperature of the sewage is above 50° F. In other words, the principal effect low temperature has upon the process is additional air requirement.

### Sedimentation.

Next to sludge disposal the most important problem studied at Milwaukee during the last six months has been sedimentation. Soon after the plant was placed in operation it was clearly proven that the sedimentation tank was not properly designed to take care of activated sludge. This tank was of central-feed, vertical-flow type, with bottom sloping at 45° towards a central well 4 ft. in diameter and 34 ft. deep below liquor surface.

It was expected that the sludge would separate from the liquor while passing from the center feed, 3 ft. below water surface, to a weir forming the circumference of the 30-ft. diameter tank, and falling upon the sloping bottom to the central well would become compressed, due to 34 ft. of head of water, and would contain about 96 per cent moisture, in which condition it would be pumped back by air into the raw sewage channel, by which it would enter the aerating tanks.

It was found that the entrance velocity was too great; that adverse currents were established which held the finer flock in suspension, permitting it to pass over the weir with the effluent; the heavier sludge would settle upon the sloping bottom and not slide down to the central well, but stick upon this bottom and become septic. While much of the sludge would reach the central well there was not enough of it to keep the aerating tanks well seeded unless an excessive volume of the nitrified liquor was returned with the sludge. This extra liquor decreased the detention period in the aerating tanks, and correspondingly reduced the aeration.

To increase the sedimentation area No. 11 sludge tank was improvised into a horizontal-flow sedimentation tank. It was soon learned that a horizontal flow at the rate of 3 ft. per minute was sufficient to give good sedimentation, but there was nothing gained in a great length of flow. In the first experiment the length of flow was about 100 ft. with 6 ft. 3 in. width channel. This successfully treated about 400,000 gal. of liquor per day. Subsequently this channel was divided into three separate sedimentation channels and satisfactorily treated about 700,000 gal.

From the experiments so far conducted upon sedimentation the indications are that the proper type tank is a long narrow vertical-flow tank with the liquor passing across the narrow dimension. The depth seems to have little influence except that it should be such that the bottom be formed as a cone with sides sloping 69° or more from the horizontal. The draw-off pipe should form the apex.

The sedimentation tank which has given the best results in Milwaukee has the following proportions: Ratio of breadth to length is as 1 is to 2.3 with flow across the breadth; 1 sq. ft. area to 1,622 gal. of sewage treated per day; effluent from aerating tank fed directly into sedimentation tank under a baffle 32 in. below surface of liquor in the latter tank.

It is desirable to build the sedimentation tanks in small connected units for two reasons, to decrease the depth, owing to slope of sides necessary, and to provide for maintaining a sludge blanket, which cannot be done in a large tank. This sludge blanket acts as a filter for intercepting the light floating matters carried to the sedimentation tank. It is not necessary in order to secure a stable effluent, but only to procure one which is perfectly clear.

### Sludge Disposal.

H. R. Worthington, of New York City, erected at the station a sludge press designed by Mr. Berrigan. This press was in operation early this year, and has been in service intermittently up to date. The Simplex Ejector Co., of Chicago, also erected and is now operating a sludge press.

Several runs have been made with the Smith type of indirect steam dryers operated at the Plankinton packing house in Milwaukee, to determine the ability of this type of dryer to treat the activated sludge and incidentally the cost. These runs involved the drying of from 3,000 lb. to 6,000 lb. per run, during which time all information was secured to determine power, labor and steam used and character of escaping gases.

In addition to this, small experiments have been made with a direct-heat dryer manufactured by the Buckeye Dryer Co., of London, O., which gave such promise as to economy and character of product that one was ordered made, which it was hoped to have in operation by the latter part of September. From the experiments made with this dryer its manufacturer has submitted a proposition, containing guarantees as to cost of operation, for erecting sufficient dryers to take care of our product.

It is felt that sufficient information has been secured to conclude that there is no difficulty in reducing the Milwaukee sludge to a marketable low-grade fertilizer at less than its value. The conclusions stated regarding pressing of sludge have been reached solely from the operation of the Berrigan press. The experiments with the Simplex press were begun at the time Mr. Hatton was preparing his paper.

After operating the Berrigan press for several months continuously, during which time many improvements were made thereto, the amount of sludge cake produced in one pressing increased from 70 lb. to 1,700 lb. with an average moisture content of 75 per cent. With a trial run, and with the crude facilities for handling the material, 6,000 lb. of pressed cake were produced in one day. This can easily be increased to 8,000 lb., or five pressings, per day when proper apparatus is provided.

One direct heat dryer can produce 25 tons per day, or about 1 ton per hour, of dried material containing 10 per cent moisture from pressed cake containing 75 per cent moisture. With mechanical stokers attached to the dryers and proper mechanical devices provided for feeding the dryers with raw material and for taking away the dried product the labor cost can be reduced to a minimum in case direct heat dryers are used. With indirect steam dryers the labor costs would be considerably increased. as the operation is intermittent and the dryers must frequently be partially cleaned by hand.

On the other hand, the gases from the direct heat dryers are more pungent and difficult to handle than those from the indirect dryers, but with a dryer plant located close by the aerating tanks, the gases, after being washed, can be discharged into the aerating tanks under the surface of the water, which will absorb the odors.

Several runs have been made to determine the volume of sludge containing 10 per cent moisture produced per 1,000,000 gal. of sewage treated. These runs have extended over two or three weeks and there has been great variation in the results. The average, however, indicates that 1,000,000 gal. of the Milwaukee sewage will produce from 750 to 1,000 lb. of sludge containing 10 per cent moisture.

The activated sludge, as it is pumped from the sedimentation tank, contains about 99 per cent moisture. If this is allowed to settle in a secondary tank for one hour it is reduced to 96 per cent moisture. Pressing it reduces it to 75 per cent moisture and when dried to 10 per cent moisture its weight is about 25 per cent of the weight of the pressed cake.

To better illustrate the sludge proportions it might be interesting to describe the method of operation. From the aerating sludge tank which receives the excess settled sludge from the sedimentation tank, 9,990 gal. of sludge containing 99 per cent moisture is pumped into an elevated wooden circular tank. This is allowed to settle for about one hour and about 7,510 gal. of supernatant liquor siphoned off, leaving 2,480 gal. of sludge containing about 96 per cent moisture. This sludge is then run by gravity into the press and reduced to 2,874 lb. of cake containing an average of 72 per cent moisture. The cake is then put into the dryer and reduced to 718 lb. of material containing about 10 per cent moisture. The above is the description of some representative runs that have been made. The weight of the cake produced is directly proportional to its moisture content and, with the present crude method of gaging, cannot always be uniform with each pressing.

From the data collected from the many experiments, the cost of disposing of the sludge for the 100,000,000-gal. plant being designed for Milwaukee will be approximately as follows:

PRESSING PER DRY TON.

| | | |
|---|---|---|
| Overhead charges, 10 per cent of cost | $1.21 | |
| Labor, eight hours, three shifts | 1.36 | |
| Clearing and upkeep of bags | .64 | |
| Power | .09 | |
| Contingencies | .16 | |
| Total cost of pressing exclusive of building | | $3.46 |

DRYING PER DRY TON

| | | |
|---|---|---|
| Overhead charges, 15 per cent of cost | $0.39 | |
| Labor, eight hours, three shifts | .73 | |
| Fuel, 1 cent per 82,000 B. t. u. | 1.10 | |
| Power, 1 cent per kw. hr. | .52 | |
| Contingencies | .13 | |
| Total cost of drying exclusive of building | | $2.87 |
| Total cost of dewatering sludge per dry ton | | $6.33 |

These costs, when reduced to the 1,000,000 gal. of sewage treated, become $1.30 for pressing and $1.08 for drying, or a total of $2.38. The cost of pumping sludge from settling tank to press is not included in above because the height to which the sludge must be lifted has not been determined.

Several tons of sludge have now been pressed and dried and the analyses show an average of 5 per cent of available ammoniacal nitrogen in the product. In normal times this is worth $12.50 per dry ton at the plant.

One of the good features of the activated sludge is the lack of unpleasant odors. Tons of pressed cake have been dumped into a small wooden shanty, more particularly to keep flies from breeding. The odor at no time during this excessive and long continued hot weather has been objectionable 10 ft. away from the building, and now when the door is opened an odor like garden soil is the only one apparent, and the sludge is gradually drying.

This clearly indicates that in a small plant, which would not warrant the cost of drying, the pressed cake could be stored for months without nuisance, and used as a fertilizer in the locality in which it was produced at such times as may be convenient.

### General Notes.

The cost of operating the process depends largely upon the overhead charges due to first cost, power and character of effluent required, all of which are bound to vary in different localities.

Any standard effluent can be secured and maintained by varying volume of air used and period of aeration, using a uniform percentage of activated sludge. This activated sludge, however, must be kept in prime condition to get any results, and this process requires a certain amount of air applied for a certain period. This cannot now be determined with a certainty until our present experiments on economy in aeration are completed, but so far we have been able to maintain good sludge by using 1.5 cu. ft. of air per gallon of sewage treated and a contact period of 4 hours, that is when the temperature of the sewage is over 50° F. Below this about 50 per cent more air is required in the same period of contact.

Good results were obtained by mixing from 5 per cent to 20 per cent of activated sludge with the raw sewage. This 5 per cent variation seems to produce no important difference in the character of effluent.

The south experimental tank for the past eleven months has been operating at the rate of 9.46 million gallons per acre per day. Since this tank has been improved the rate has been raised to 10 million gallons and is expected to go higher.

One point must be kept well in mind. The mixture of sewage and sludge as it discharges from the aerating tanks cannot be carried in conduits unless it is constantly agitated, as the sludge will settle in the conduits immediately.

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## CONSTRUCTION COSTS OF CERTAIN RAPID SAND FILTER PLANTS.

In reporting on a new water supply for Sacramento, Cal., the engineers, Messrs. Hyde, Wilhelm and Miller, presented a tabulation to permit a comparison between the estimated cost of the proposed purification works outlined in their report and the costs of similar structures of the same character built elsewhere in the United States. The comparisons, of course, are rough, since no two plants have identical conditions to meet and therefore are not exactly alike. The figures, however, are of interest as showing the general investment requirements in plants of this character. In the table, that follows, the cost figures are given per 1,000,000 gal. nominal daily capacity of filters, and are supposed to include coagulation basins, filters, head and filter houses and filtered water basins:

| Name of place. | Nominal capacity of filters 1,000,000 gal. per day. | Capacity of coagulant basins 1,000,000 gal. | Capacity of filtered water basins 1,000,000 gal. | Construction cost per 1,000,000 gal. nominal daily capacity. |
|---|---|---|---|---|
| 1. New York (proposed) | 320 | 88 | 365 | $16,100 |
| 2. Baltimore, Md. | 128 | 16 | 17.8 | 10,900 |
| 3. Cincinnati, O. | 112 | 22.5 | 19.5 | 11,400 |
| 4. New Orleans, La. | 40 | 42.2 | 15.4 | 30,200 |
| 5. Minneapolis, Minn. | 39 | 5.6 | 50 | ...... |
| 6. Toledo, O. | 39 | 10 | 26 | 14,500 |
| 7. Little Falls, N. J. | 32 | 7 | 3.5 | 15,000 |
| 8. Columbus, O | 30 | 15 | 10 | 15,200 |
| 9. Trenton, N. J. | 30 | 3.8 | 1.2 | 12,000 |
| 10. New Milford, N. J. | 24 | 11.5 | 2.0 | 11,000 |
| 11. Grand Rapids, Mich. | 16 | 2.6 | 2.8 | 16,300 |
| 12. Niagara Falls, N. Y. | 16 | 2.0 | 0.5 | 16,000 |
| 13. Harrisburg, Pa. | 15 | 0.33 | 0.62 | 10,300 |
| 14. Dallas, Texas | 15 | .... | ... | 13,000 |
| 15. Evanston, Ill. | 12 | 0.83 | 2.0 | 17,000 |
| 16. Flint, Mich. | 8 | 1.25 | 2.0 | 18,000 |
| 17 Watertown, N. Y. | 8 | .... | ... | 11,300 |
| 18. Lorain, O. | 6 | 0.58 | 0.29 | 14,000 |
| 19. Steubenville, O. | 6 | .... | ... | 22,000 |
| 20. Jackson, Miss. | 4 | .... | ... | 17,000 |
| Straight averages | 45 | 14.3 | 32.4 | $15,330 |
| Weighted averages | .. | .... | .... | 13,700 |
| Sacramento proposed* | 30 | 11.0 | 5.0 | $13,800 |

Authorities: Journal of the American Water Works Association, 1914; (1) G. A. Johnson, p. 512; (2) Including low lift pumping station, J. W. Armstrong, p. 497; (3) G. A. Johnson, p. 69; (4) Including very expensive foundations, etc., J. H. Gregory, p. 473; (5) Not available at this date; (6) J. H. Gregory, p. 472; (7) G. A. Johnson, p. 69; (8) Excluding softening works, G. A. Johnson, p. 511; (9) G. A. Johnson, p. 521; (10) G. A. Johnson, p. 69; (11) J. H. Gregory, p. 472; (12) C. B. Buerger, p. 492; (13) G. A. Johnson, p. 69, (14) G. A. Johnson, p. 69; (15) C. B. Buerger, p. 492; (16) C. B. Buerger, p. 492; (17) G. A. Johnson, p. 69; (18) G. A. Johnson, p. 69; (19) C. B. Buerger, p. 492; (20) C. B. Buerger, p. 492.

*The Sacramento estimates do not include land or low lift pumping equipment.

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## SAND COLLECTING DEVICE.

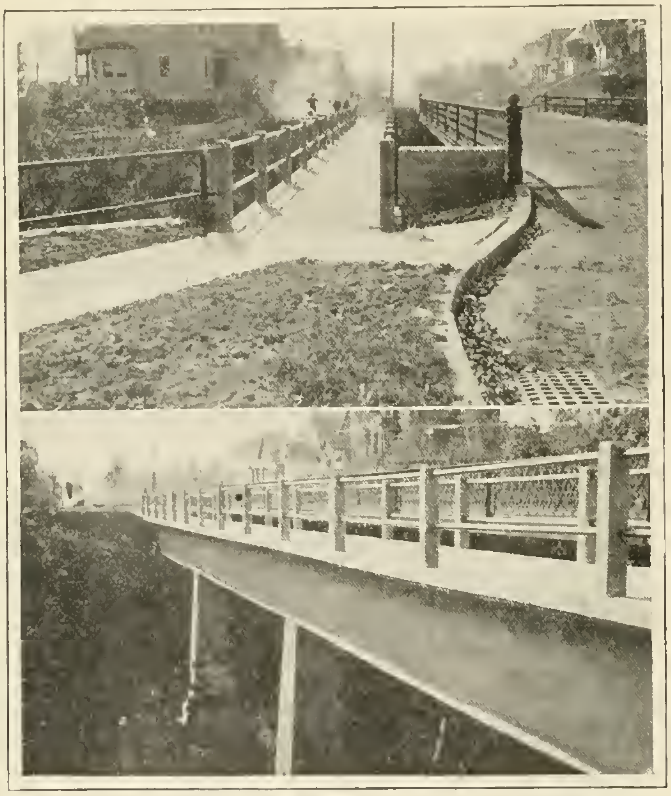
An interesting device is used at the Chain of Rocks filtration plant of St. Louis, Mo., for collecting from the filter beds samples of the sand at various depths simultaneously. The arrangement consists of 15 telescoping copper cans 3 in. in diameter and 3 in. high, provided with $\frac{1}{4}$-in. by $\frac{3}{4}$-in. openings near the top, covered with rubber slip valves, each having an air vent projecting above the water when submerged. The cans, fastened on a frame, are lowered into the sand while washing, and all the slip valves being removed at once a good sample (nearly two-thirds of a canful) can be obtained at the various depths.

## A NOVEL REINFORCED CONCRETE SEWER VIADUCT.

Contributed by Frank C. Perkins, Buffalo, N. Y.

The accompanying illustrations show the construction of a novel reinforced concrete sewer viaduct which was recently built in Duluth, Minn. It is pointed out by Engineer E. Dow Dilman of the Division of Public Works of Duluth, Minn., to whom the writer is indebted for photographs and data, that there are a number of gulleys and ravines, which, with the steep grades encountered, make the municipal engineering problems costly and difficult in that city.

It was found that 8-in. pipe in Fifth St., from 18th to 24th Aves., east, was inadequate to carry the sewage from the rapidly developing territory which it served, and plans were prepared for a 15-in. relief sewer. The old 8-in. pipe is carried across the ravine at 22d Ave., east, in a wooden housing supported by a pipe trestle. The Assistant Engineer states that this has never been satisfactory as it has leaked, requiring high maintenance costs, and cannot be considered a permanent structure. It was decided to use a reinforced concrete viaduct to carry the 15-in. pipe across the ravine. The original design for the viaduct was for a girder type of three spans, about 36 ft. long, each. The girder was designed to carry only the sewage and wind and snow loads, the top being designed an A-shape.



Combination Footway and Sewer Pipe Viaduct at Duluth, Minn.

When the work was well under way, the piers completed, and all the steel had been delivered and bent to shape, the possibility of using the structure to serve a double purpose became apparent. The roadway is carried across the ravine by a bridge only 20 ft. wide, on which no foot walk is provided. Pedestrians were forced to step into the street, where in wet weather they were splashed with mud from passing vehicles. The line of the sewer, which was laid in the boulevard back of the curb, was nearly on the line of the sidewalk, and the grade was such that the top of the viaduct would come but slightly below the elevation of the walk.

It is stated that the location is in one of the best residence districts in Duluth, and the plain concrete viaduct would have been an unsightly addition. The idea of providing a walk over the top of the viaduct was suggested to the City Council and was approved. The steel already on hand had to be used. The stirrups bent to the original design were not high enough, and the shear above the stirrups was cared for by bending the reinforcing bars of the cantilever walk down to the center of the beam. Additional steel was required in the bottom and was provided by additional rods. It would have been preferable to have provided and required area by a fewer number of larger units, but with the change in design this was impossible.

In the endeavor to make the additional cost as low as possible, Engineer Gilman states that concrete posts instead of iron posts were used. This did away with a large number of costly fittings and allowed stock lengths of pipe to be used. The result was not only economical, but was also more pleasing in appearance than the pipe posts would have been. The design of the piers had been determined by their appearance of stability. Piers of just sufficient size to have carried the load would have been unsightly, slender supports. Therefore no changes were necessary in the design of the piers. No expansion joints were used, though two layers of tar paper were placed over each abutment to allow of some sliding at these points.

The sewer in this district is used for both storm and sanitary sewage and the relief sewer was to be used only during the rainy months, and it was unnecessary to provide against freezing. A 15-in. galvanized iron pipe was used as a form through the viaduct. It is of interest to note that the total cost of the structure, including all engineering expense, materials, labor and supervision, was $1,792.82, of which the rails and posts cost $100.37, with a unit cost of $0.43 per linear foot of railing, while the total added cost due to the walk was $348.31, a unit cost of $0.51 per square foot.

In this structure, 86 cu. yd. of concrete were used, making a total unit cost for the whole job of $20.86 per cubic yard, while the cost of the material was $961.76 with a labor cost of $716.45, the engineering and supervision amounting to $114.61, all of which are higher than they would be for duplicating the work if originally designed as finally constructed.

## BEHAVIOR OF LIMESTONE STREAMS DURING DROUGHT.

An interesting comparison of the yields of streams draining limestone and non-linestone areas during times of drought is given in the lately issued 1915 report of the Water Supply Commission of Pennsylvania. The comparison is for Spring and Bald Eagle creeks, in Center County, whose drainage areas adjoin and are practically of the same size above the mouth of Spring Creek, near which point the Commission maintains gaging stations on both streams. The figures are as follows:

COMPARISON OF LIMESTONE AND NON-LIMESTONE YIELDS; PER CENT OF YIELD TO PRECIPITATION.

| Month. | Spring Creek (limestone.) (Drainage area, 145 sq. miles.) | | Bald Eagle Creek. (Drainage area, 140 sq. mi.†) | |
|---|---|---|---|---|
| | 1911-1914. | 1914. | 1911-1914. | 1914. |
| September | (48*) 279 | 971 | 24 | 14 |
| October | 58 | 60 | 37 | 2 |
| November | 92 | 118 | 44 | 9 |
| December | 84 | 45 | 54 | 8 |
| January, 1915 | 100 | 43 | 88 | 68 |

*Does not include 1914. †At Milesburg.

The table indicates that Spring Creek, a limestone stream, yielded nearly ten times the precipitation over its watershed during September, 1914, 60 per cent during October, 1914, 118 per cent during November, 1914, and 45 per cent during December, 1914, while the yield from Bald Eagle Creek was very low, varying between two and fourteen per cent. The natural regulation of Spring Creek is also shown by the yield of 43 per cent of the precipitation during January, 1915, which was approximately the same as for December, 1914, while the yield from Bald Eagle Creek jumped from 8 to 68 per cent due to the rains of December, 1914, and January, 1915. These figures are representative of how limestone streams draw on their subterranean sources of supply during a drought and produce much larger summer and fall rates of flow than those streams draining other geological formations, while later heavy rainfalls replenish the limestone caverns or subterranean reservoirs.

## GARBAGE COLLECTION AND DISPOSAL BY A SMALL CITY.

The Borough of Sewickley, Pa., a residential suburb of about 5,000 population, has one of the most up-to-date garbage collection systems of any city of its size in this country. An excellent description of the Sewickley method was given by Mr. Edward E. Duff, Jr., in a paper presented at the recent convention of the American Society of Municipal Improvement. Extracts from this paper are given below:

The Borough has an area of about one square mile, with a taxable property valuation of $7,250,000. Prior to 1907 the garbage was hauled to the bank of a small run within the Borough limits where it was carefully washed and subsequently buried. In 1907 a 12-ton incinerator was purchased from the Dixon Garbage Crematory Co., and erected in a suitable two-story brick building on property purchased by the Council at one corner of the Borough on the Ohio river bank.

To supply the Borough, 1,357 cans are now in active use, 1,285 of which are at the residences, and 72 on one of the wagons as exchange cans. The cans are made of galvanized iron, weigh 17¼ lb. when empty, and have a capacity of about 11 gal. They are ordered from the following specifications, which have been revised from year to year as weaknesses have developed in any feature: 12¾ in. diameter by 19½ in. high, 20 gage iron in body and bottom, 26 gage tight fitting lid 1½ in. deep, wrought iron hoops ⅛ in. by 1½ in. shrunk around top and bottom, heavy drop handles 4½ in. from top. All cans and lids must be thoroughly galvanized and be guaranteed against leakage. These cans are purchased in lots of 200 to 400 each year at prices varying from $1.00 to $1.60 each, depending on the current prices of the raw materials. The cans are subjected to hard usage and the records show their life to be from 3½ to 4 years. One of the main sources of damage is due to householders using the can as a convenient place to burn waste paper.

The cans are placed by the collectors in any location convenient for the householder, and while their use is primarily for garbage, all kinds of refuse is found in them, such as paper, bottles, cans and even occasionally a dead cat.

Two specially constructed wagons, carrying 72 cans each, were built by the Borough for the collection of the garbage. The wagons consist of a flat bed or floor set above the wheels about 4 ft. above the street level, and having a few uprights around the sides to which chains are fastened to prevent the cans from falling off. The cans are placed in six rows with twelve cans to a row and as the empty cans are taken from the wagon to replace the full cans, the driver or the collector shifts the remaining empty cans to the outside.

Collections are made once each week in the residence districts, except during the summer season when there is an unusual amount of vegetable refuse, such as corn husks, watermelon rinds, etc., when three collections are made in two weeks. The hotels, restaurants, hospital and other places where an unusual amount of garbage is found have two collections each week. From one to five cans are left at each residence and as many as 11 or 12 cans at the hospital and hotels, depending of course on the actual need and the garbage accumulating. It has been found that two cans per week give ample accommodation for the average family, and where it is necessary to supply more than two cans, the additional cans must be purchased by the householder, and these, of course, are exchanged the same as those owned by the Borough. In collecting, the lids are not removed from the cans from the time they leave the residence until they reach the furnace, and there is consequently no nuisance created emptying from one can to another or from the can to a wagon. The lids fit tight, and the cans are kept so clean that there is little or no odor about the wagon. The usual unpleasantness generally associated with a garbage wagon, such as the rattling and banging of cans and the slamming of the doors on the familiar steel wagon, is conspicuous by its absence.

The present needs require the use of only one team of horses and one wagon in the collection work, the second wagon being loaded at the furnace for the next trip. In charge of a driver and collector, both of whom, however, act as collectors when necessary, each taking one side of a street, the wagon makes four trips per day, bringing 285 cans to the furnace having a total average net weight of four tons. This is at the rate of 85,540 cans per year, having a weight of 1,200 tons. An additional ton of garbage is received each day in bulk from the grocery and fruit stores, making a daily incineration of five tons and a yearly incineration of about 1,500 tons.

The Borough is 1 mile long and approximately 1 mile wide, so that in going from the garbage furnace to the diagonally opposite corner of the Borough, the garbage wagon covers on the round trip about 3⅓ miles, making collections, however, for only ¾ of a mile in this distance. The shortest route is 1¼ miles and collections are made for only ½ mile before the wagon is loaded. Due to more convenient location of the cans in the first mentioned district, the trip is completed in 2 hours, while it requires 1½ hours to do the work on the short trip. Eighteen routes are covered by the wagon in 4½ days, in which time one collection is made throughout the Borough. The remaining day and one half is used making the second collection for the week in the business district.

Upon arriving at the furnace with a load, the wagon is left in front of the big door of the furnace building, and while the driver is hitching the horses to the extra wagon, which has previously been loaded with clean empty cans, the collector assists the furnace man in emptying the garbage into the incinerator until such time as the driver is ready to leave, which is usually about five minutes.

During the winter months when the wet garbage is frozen it is necessary to thaw the garbage before it can be emptied from the can. A short application of a jet of steam from the hot water heater will allow the garbage to be removed. The use of bars or hooks for this purpose is prohibited because of the damage likely to occur to the cans.

In the period of 1½ to 2 hours usually elapsing between loads, the furnace men allow 15 minutes to empty garbage into the furnace, 20 minutes to wash the cans, and 25 minutes to load the 72 cans on the extra wagon and arrange it for the next trip. The remaining time is spent firing the furnace, hauling ashes, etc.

Coal is used in the furnace to burn the garbage, while coke is burned in the flue to complete combustion. Although the garbage plant is located within 300 yd. of some of the best residences there is no complaint at any time of objectionable odor.

All the cans are thoroughly cleaned with scalding water before they are again placed in active use. Five cans are placed on a rack at one time, and after they are thoroughly clean, they are placed on the wagon for service. It is very seldom that complaints are received regarding dirty cans.

The total investment, exclusive of real estate, might be distributed as follows:

| | |
|---|---|
| Building, driveway, platform and incinerator | $ 8,500 |
| Stable | 2,000 |
| Two horses and harness | 700 |
| Two wagons | 400 |
| 1,357 cans at average price, $1.25 | 1,696 |
| Total | $13,296 |

The average of the yearly charges for the past eight years and ten months to January 1st, 1916, as taken from the annual report of the Borough Clerk, show:

| | |
|---|---|
| Wages (driver, collector, two furnace men) | $2,699 |
| Coal and coke (about 650 tons per year) | 651 |
| Freight on coal, coke, firebrick, etc. | 330 |
| Repairs (relining furnace, grate, bars, etc.) | 257 |
| Insurance (fire insurance on buildings and platform) | 33 |
| Horse feed | 389 |
| Blacksmithing | 104 |
| Cans | 313 |
| Extraordinary expense (rebuild driveway and platform, etc.) | 76 |
| New horses | 92 |
| Credit (sale of cans and coal) | 33 |
| Total average cost per year | $4,997 |

Of this total amount, one-half of the cost of wages (2 men), all of the coal and coke, 90 per cent of freight charges, 90 per cent of repairs, all insurance, 10 per cent of blacksmithing and one-half of the miscellaneous, making a total of $2,616 are charged entirely to incineration, leaving a balance of $2,381 as the cost of collection. This amount is raised by about seven-tenths of a mill tax on the valuation of $7,250,000.

On the basis of the above figures, and exclusive of any interest on the investment or sinking fund charges, it has cost $1.00 per inhabitant per year to collect and incinerate the garbage, of which amount 52 ct. was spent for incineration and 48 ct. for collection. On the basis of 1,500 tons per year, it has cost $3.33 to collect and incinerate each ton.

## SEWAGE TREATMENT PLANTS IN OHIO.

A classification of the sewage treatment plants in Ohio is given in an appendix to the report of the Committee of Sewage Works Operation and Analytical Methods of the Sanitary Engineering Section of the American Public Health Association, presented on Oct. 26 at the Cincinnati meeting. The classification was prepared by Mr. W. H. Dittoe, Chief Engineer of the Ohio State Board of Health and is as follows:

Class 1—Municipal sewage treatment plants. These include plants of various types installed to serve the entire area of a municipality or the major portion thereof.

Class 2—Sewage treatment plants for realty allotments and districts of a municipality. These include plants principally installed as private enterprises in connection with the development of real estate either within or without an incorporated municipality. They also include plants which serve small sections of a municipality.

Class 3—Sewage treatment plants for individual establishments. These include plants installed for the treatment of sewage from industrial plants and are not to be confused with plants installed for the treatment of industrial wastes.

Class 4—Sewage treatment plants for public institutions. Public institutions cover state, municipal and county institutions.

Class 5—Sewage treatment plants for private institutions, country clubs, etc.

Class 6—Sewage treatment plants for summer resorts, chautauqua grounds and summer camps.

Class 7—Sewage treatment plants for school buildings.

The following table gives the number of plants in each class at present existing and under construction.

EXISTING SEWAGE TREATMENT PLANTS IN OHIO, AUGUST, 1916.

| Population designed for— | Less than 500. | 500 to 10,000. | Over 10,000. | Total. |
|---|---|---|---|---|
| Class 1 | 1 | 49 | 6 | 56 |
| Class 2 | 10 | 1 | .. | 11 |
| Class 3 | 6 | 1 | .. | 7 |
| Class 4 | 31 | 9 | .. | 40 |
| Class 5 | 13 | 1 | .. | 14 |
| Class 6 | 1 | 3 | .. | 4 |
| Class 7 | 30* | .. | .. | 30 |
| Totals | 92 | 64 | 6 | 162 |

*Approximately.

The data regarding the first 6 classes are as accurate as it is possible to obtain it. The approximate number of installations for treatment of sewage from school buildings is given. During the years 1912 to 1916 (August 1st) the State Board of Health has approved plans for sewage treatment devices for 60 school buildings and it is estimated that about 30 of the installations have been made. They include treatment devices ranging from tanks to complete plants involving intermittent sand filters.

In addition to the existing plants given in the table, 6 plants under Class 1 are being constructed. Three of these are designed for populations between 500 and 10,000 and 3 for populations over 10,000. The Columbus plant is the only one at present having laboratory control. However, provision for laboratory control has been made for the new plants at Akron, Canton, Alliance and Sandusky.

## ESTIMATED COSTS OF HYDROELECTRIC PLANTS ON WINNIPEG RIVER.

Estimated costs based on actual experience under similar conditions are always interesting and often of great value. The Canadian government has just published a "Report on the Winnipeg River Power and Storage Investigations," by J. T. Johnston, Chief Hydraulic Engineer. The report is a 500-page volume, remarkable for its completeness. It summarizes the engineering investigations and estimates relating to seven proposed developments totaling 313,500 hp., at an estimated average cost of $78 per hp. at the power sites, exclusive of transmission lines.

In the estimates it will be noted that 10 per cent was allowed for contingencies, 5 per cent for engineering and inspection, and 5.5 per cent for interest during construction. We give below the first cost and annual cost of one of these developments, that at Pine Falls, totaling 100,000 hp.

The question of the advisability of publishing detail capital and operating cost estimates was at first debated, as it was felt that they might be open to criticism and that conditions changing with the passage of time would possibly very materially alter the published figures. It was thought, however, that the advisability of supplying prospective users of power with some conservative and authoritative measure whereby the economic as well as the engineering merits of the various sites could be readily compared, and with which competing sources of power could be analyzed, more than outweighed other considerations. To neutralize possible future criticism of the published estimates, care has been taken to supply such plans and data covering each site as will enable independent estimates being made by any parties interested in its development.

In view of the fact that it is not possible at this stage to foretell which plants along the Winnipeg River will be utilized for the purpose of transmitting power to the industrial centers of Manitoba, and which ones will develop power for local use, the cost estimates place the power on the low tension switchboard in the power station. With the exception of Pine Falls site no allowance has been made for transformation and transmission. The purpose of the estimates has been primarily to arrive at the capital cost of the actual development of the independent sites, and by standardization, both as to design and as to unit prices, to compare the sites with each other from the viewpoint of their economic feasibility. Since the basis of estimates is standardized throughout, a study of the results submitted herewith will be found of interest.

The general costs quoted are based on a 24-hour output, at 75 per cent over-all efficiency, as this forms a uniform and, considering the more than 90 per cent efficiencies claimed for modern turbine runners, conservative measure for comparison. The figures on this basis, scarcely do the developments justice, since in them no account is taken of peak loads and of the re-sale of power such as is always possible in plants projected for the supply of power for general industrial and lighting consumption. In all designs ample machine capacity has been allowed to care for all peak loads which can be reasonably expected, and to supply spare units for emergencies. This over-development has added largely to the estimated cost of the plants and hence to the unit cost when the latter is based on 24-hour power. On the other hand, costs per horse-power, based on the installation, frequently convey erroneous ideas as to economic efficiencies, since local conditions or an auxiliary steam plant frequently permit the excessive over-development of a particular power site in proportion to the dependable power available from the river. However, in the designs and estimates considered herein, the machinery installed bears, in all cases, a definite ratio to the power in the river, and this ratio cannot be considered too high in plants handling normal industrial and lighting loads. The unit costs based on installation can therefore be profitably studied in conjunction with the unit costs on a 24-hour basis.

In all cases provision has been made for access to the site by rail, or in the case of the Pine Falls plant, by water. In each case 10 per cent has been allowed for contingencies, 5 per cent on this total for engineering and inspection, and 5½ per cent on the whole for one year for interest during construction.

The actual cost of the construction of the two existing plants on the river has been carefully studied and compared with the estimated costs of the various proposed developments. Independent estimates by private engineering firms have also been found to check closely with the capital costs herein submitted. The estimates may therefore be taken as setting out conservatively and closely the capital construction cost of the proposed sites.

As in the case of the capital costs, the annual operation costs have been estimated to a uniform standard, and hence form a measure whereby the commercial prospects of the different projects can be readily compared.

The operation costs include capital charges and are published in terms of cost per horse power year 24-hour power; cost per horsepower year machinery installed; cost per kilowatt hour at 100 per cent load factor, and cost per kilowatt hour at 50 per cent load factor. These costs represent the operating charges at the power station, and do not include transforming and transmission.

In order to secure a proper understanding of the cost of power in Winnipeg, the estimated cost of transmitting power from the Pine Falls site to Winnipeg has been included.

In view of the involved nature of the storage situation in the upper water-shed, the proportionate cost of storage reservoir construction has not been included in the estimates of the various sites. The necessary steps to insure 20,000 second-feet minimum flow are dependent largely upon the course of power development.

Final Development.—(Ten 10,000-hp. units.)

(1) CAPITAL COST OF INSTALLATION.

| | | |
|---|---|---|
| Dam and equipment | $ 381,000 | |
| Ice sluices | 61,000 | |
| Power station and equipment | 958,000 | |
| Hydraulic installation | 900,000 | |
| Electrical installation | 1,200,000 | |
| Dockage facilities | 50,000 | |
| Permanent quarters | 25,000 | |
| Contingencies, 10 per cent | 358,000 | |
| Engineering and inspection, 5 per cent | 197,000 | |
| Interest during construction, 5½ per cent | 227,000 | |
| Flooding damages | 50,000 | |
| Total final cost | | $4,407,000 |
| Twenty-four hour power available at 75 per cent over-all efficiency, 63,100 horsepower. | | |
| Capital cost per 24-hour horsepower | | 69.84 |
| Capital cost per installed horsepower | | 44.07 |

(2) ANNUAL COST OF OPERATION.

| | | |
|---|---|---|
| Interest, sinking fund, and depreciation charges— | | |
| Interest, 5½ per cent on $4,407,000 | | $ 242,000 |
| Sinking fund, 4 per cent (40-year bonds) | | 16,000 |
| Depreciation— | | |
| 1 per cent on permanent works | $12,000 | |
| 1 per cent on machinery, etc. | 90,000 | |
| | | 102,000 |
| Operation charges— | | |
| Staff | $29,000 | |
| Supplies | 28,000 | |
| | | 57,000 |
| Total annual charge | | $ 417,000 |
| Annual cost per horsepower year, 24-hour power | | $7.08 |
| Annual cost per horsepower year, machinery installed | | 4.47 |
| Annual cost per kilowatt hour | | 0.108 cent |
| Annual cost per kilowatt hour on basis of 50 per cent load factor | | 0.216 cent |

An analysis of the power situation would, however, be incomplete unless some idea were given as to the cost of transmitting the power to the nearest industrial market, i. e., the city of Winnipeg. To this end, the following estimate of cost of transmission from the Pine Falls site to the low-tension switchboard in the transformer house in Winnipeg is appended.

The estimates herewith are based on an intial and final development; the capital cost to the low-tension switchboard in the power station has been brought forward from the detailed estimates of the Pine Falls development. The transmission distance is 60 miles.

The power station as designed does not include provision for step-up transformers, and hence a separate building has been provided at the site, together with a step-down station in Winnipeg. At the river station six 6,000 k.w., 6,600-66,000-volt transformers have been provided for the initial installation, and ten in the final. In the Winnipeg station corresponding provision has been made after allowing for a 10 per cent line drop. The resulting costs place the power ready for distribution in Winnipeg.

Final Development.—(Ten 10,000-hp. units.)

(1) CAPITAL COST OF INSTALLATION.

| | | |
|---|---|---|
| Capital cost of installation to low-tension switchboard at falls, brought forward | | $4,407,000 |
| Transformer house at falls | $ 80,000 | |
| Transformers, switches, wiring, etc | 360,000 | |
| Transmission line | 420,000 | |
| Transformer house in Winnipeg | 70,000 | |
| Transformers, switches, wiring, etc | 321,000 | |
| | | 1,251,000 |
| Total final cost | | $5,661,000 |
| Twenty-four hour power available in Winnipeg, considering 10 per cent loss, 56,790 horsepower. | | |
| Capital cost per horsepower | | $99.68 |

(2) ANNUAL COST OF OPERATION.

| | | |
|---|---|---|
| Interest, sinking fund, and depreciation charges— | | |
| Interest, 5½ per cent on $5,661,000 | | $ 311,000 |
| Sinking fund, 4 per cent (40-year bonds) | | 60,000 |
| Depreciation— | | |
| 1 per cent on permanent works | $ 14,000 | |
| 4 per cent on machinery, etc | 134,000 | |
| | | 148,000 |
| Operation charges— | | |
| Staff | $ 15,000 | |
| Supplies | 25,000 | |
| | | 70,000 |
| Total annual charge | | $ 589,000 |
| Annual cost per horsepower year 24-hour power | | $10.37 |
| Annual cost per kilowatt hour | | 0.159 cent |
| Annual cost per kilowatt hour on basis of 50 per cent load factor | | 0.318 cent |

As noted in connection with the operating costs at the power sites, 24-hour continuous power is a most conservative basis on which to base annual costs. The conditions under which the Pine Falls plant will operate are such that of the above two figures, 0.159 cent per kilowatt hour the more nearly represents the cost of power laid down in Winnipeg.

## TWO YEARS OF OPERATION OF PANAMA CANAL.

Two years of the operation of the Canal were completed at the close of business on Aug. 14, 1916, the Canal having been opened to commercial traffic on Aug. 15, 1914.

During the two years a total of 2,097 ships made the transit. Their aggregate net tonnage, according to the rules for the measurement of vessels for the Panama Canal, was 7,046,407. The total quantity of cargo carried through the Canal by them was 9,031,613 tons of 2,240 lb.

A summary of the movements each way during the two calendar years is given in Table I from the Panama Canal Record.

During the year from Aug. 15, 1915, to Aug. 14, 1916, the Canal was closed approximately one-half the period, from the middle of September to the middle of April. The second year had 59 per cent as many ships as the first, 53.3 per cent as much net tonnage, and 52.8 per cent as much cargo.

Collections of tolls for the two years have aggregated $7,411,682.26. A summary of the earnings by months is given in this tabulation:

| Month | Tolls. | Month. | Tolls. |
|---|---|---|---|
| August 15 to 31 1914 | $ 88,401 | August 15-31, 1915 | $ 303,879 |
| September | 265,600 | September | 349,498 |
| October | 366,786 | October | ....... |
| November | 369,161 | November | ....... |
| December | 407,914 | December | 10,826 |
| January, 1915 | 398,601 | January, 1916 | 654 |
| February | 383,904 | February | 834 |
| March | 551,092 | March | 418 |
| April | 442,415 | April | 235,618 |
| May | 522,676 | May | 368,023 |
| June | 539,229 | June | 363,799 |
| July | 573,365 | July | 460,122 |
| August 1-11, 1915 | 192,912 | August 1-14, 1916 | 215,943 |
| Total first year | $5,102,063 | Total second year | $2,309,618 |

TABLE I.

| | Atlantic to Pacific | | | Pacific to Atlantic | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vessels. | Canal net tonnage. | Tonnage of cargo. | Vessels. | Canal net tonnage. | Tonnage of cargo. | Vessels. | Canal net tonnage. | Tonnage of cargo. |
| First year | 656 | 2,310,500 | 2,562,482 | 661 | 2,286,144 | 3,346,623 | 1,317 | 4,596,644 | 5,909,105 |
| Second year | 399 | 1,275,524 | 1,424,291 | 381 | 1,174,239 | 1,698,217 | 780 | 2,449,763 | 3,122,508 |
| Total | 1,055 | 3,586,024 | 3,986,773 | 1,042 | 3,460,383 | 5,044,840 | 2,097 | 7,046,407 | 9,031,613 |

## FLEXIBLE FLOATING PUMPING PLANT ON CALUMET-SAG CHANNEL.

An economical floating pumping installation is employed by James O. Heyworth, contractor, Chicago, Ill., on Contract No. 11 of the Calumet-Sag Channel of the Sanitary District of Chicago. The east end of this work is located about one mile west of Blue Island, Ill. The channel at this point is about 39 ft. deep from the normal surface of the ground, down to grade, and as the cut passes through more or less soft material, water collects in the channel and must be pumped out while the work is being done. For this purpose the floating pumping plant shown in Fig. 1 is used. This plant consists of a barge about 16 ft. wide by 20 ft. long, having mounted on it two 8-in. American, type DSMD, horizontal, single stage, double suction centrifugal pumps, each designed to deliver 2,000 gal. per minute against 50 ft. total head, and each driven by a 35 H.P., 3-phase, 60-cycle, 440-volt, General Electric, squirrel cage motor of 865 R.P.M. full load speed.

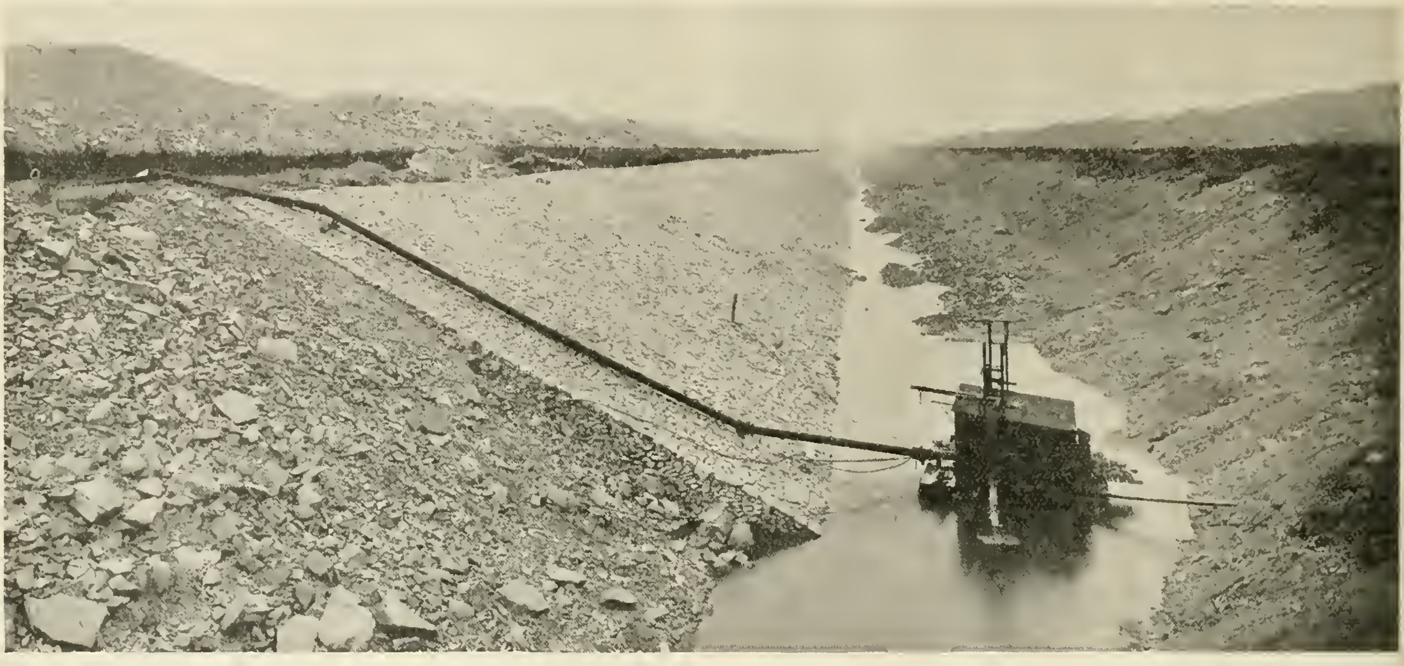


Fig. 1—Pumping Plant of James O. Heyworth on Contract No. 11. Calumet Sag Channel.

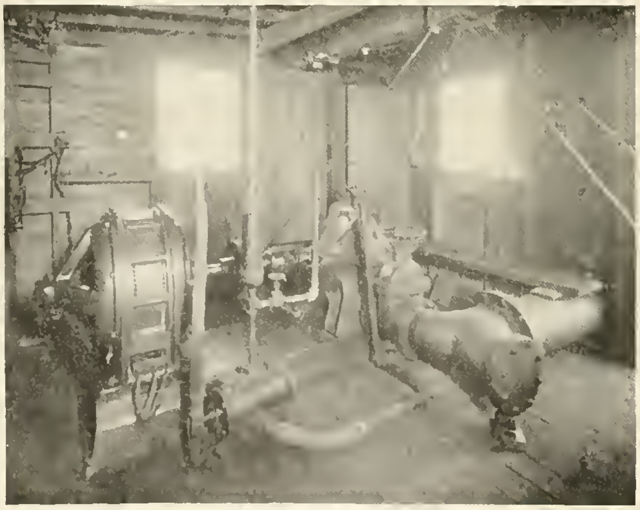


Fig. 2—Interior View of Pumping Plant.

The units stand side by side with parallel shafts, the suctions being on opposite sides of the barge. Each suction pipe is 10 in. in diameter and is equipped at the point where the pipe passes through the wall of the barge, with a 10-in. Barco ball and socket joint, and the lower end of each pipe is equipped with a 45° elbow facing downward. Each suction is equipped with a Barco joint so that in case the barge settles onto the bottom of the canal, either by sinking or pumping out the water, no damage will be caused to the pumps by breaking of suction pipes, as would be the case if the connection were solid. Each suction pipe is handled by a small windlass located on top of the plant in a framework.

The discharge of the two units is brought together into a common 12-in. pipe line and each discharge is equipped with a gate valve. This 12-in. pipe extends outside of the building, and is firmly anchored to the barge. At the edge of the barge is a 12-in. Barco joint, then a 20-ft. piece of standard steel flanged pipe, and on the slope is located another ball and socket joint, and from this point to the normal ground surface, the pipe line consists of flanged asphalted spiral pipe. At the upper end of the pipe line, the water is discharged into a ditch.

The pipe line is very light in construction and can be without very much effort lengthened or shortened by putting in or taking out a length of pipe. This was the method used when the plant was first put in, as the water had to be pumped out and the plant lowered, as the canal deepened.

Due to the two ball and socket joints in the discharge line, it is possible for the plant to rise or fall through a total elevation of 15 ft. without cramping the pipe line. During the flood in January of this year, the plant was put to a most severe test, as during the few hours of rain, water collected to such an extent in the canal, that the plant floated upward 9 ft. and at this elevation with both units operating, handled something over 4,000 gal. per minute. The quantity handled by the pumps equalled the quantity coming into the canal and the barge did not rise farther, but after a few hours it drained the water out of the canal so that work could be started again.

As neither pump is equipped with a foot valve, an ordinary 5x5 double acting tank pump is used in priming. The discharge gate valve is closed and the air exhausted by means of this tank pump, at which time the motor is started, and when up to speed, the discharge gate valve is opened slowly and water is delivered into the pipe line up the side of the canal.

The illustrations show only one unit, the other having been removed temporarily to a point farther to the west on the same contract.

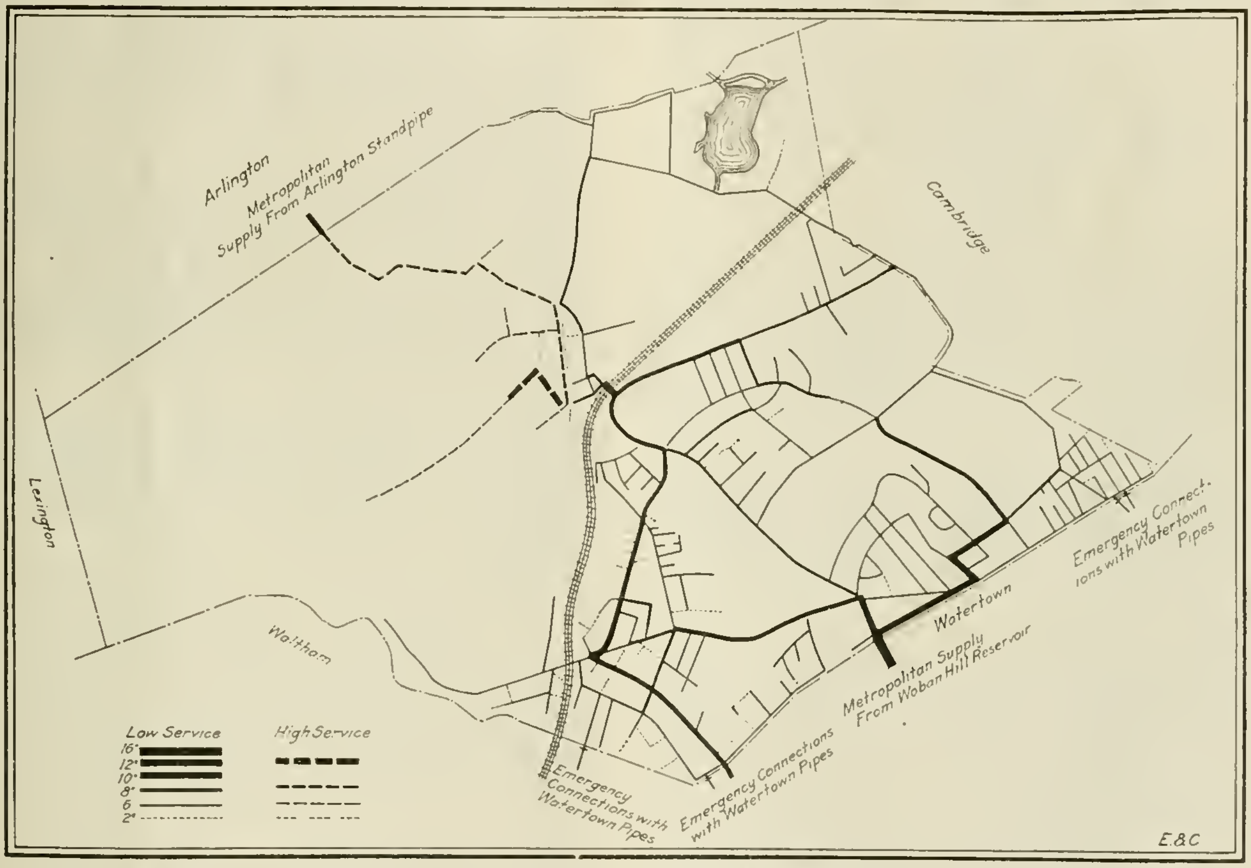
Power is obtained from Public Service Co. of Northern Illinois at a rate based on maximum demand and due to the low attendance charge and lack of repairs, it is stated that this plant is more economical than the method of pumping by steam.

## THE GRAPHICAL REPRESENTATION OF THE CAPACITY OF MAIN WATER PIPES.

Contributed by Charles W. Sherman.*

It is common practice to represent pipes of various sizes by lines of different widths, particularly on outline or key maps of water works distribution system, although it is even more common to use lines of different character, such as various combinations of dots and dashes. The latter method of representing, like the use of colors, does not admit of forming a mental picture of the system as a whole and judging the relative sufficiency of the main lines of supply. The method of varying the widths of the lines is a help, but it is much more significant if the widths of the lines are made proportional to the areas of the pipes. When this is done the relative carrying capacity can be judged at a glance—except, of course, for the effect of difference of elevation—and the result is a key plan which is of much significance.

A plan of the kind showing the piping system of the town of Belmont, Mass., is reproduced in the accompanying figure. In this map the smallest full line represents a 6-in. pipe, and all smaller sizes are shown by dotted lines. It will be noted that a 16-in. pipe requires about as heavy a line as it is feasible to use.


Arlington
Metropolitan Supply From Arlington Standpipe
Cambridge
Lexington
Waltham
Watertown
Emergency Connections with Watertown Pipes
Metropolitan Supply From Waban Hill Reservoir
Emergency Connections with Watertown Pipes
Emergency Connections with Watertown Pipes
Low Service
16"
12"
10"
8"
6
2"
High Service
E.&C.

Map Showing Carrying Capacity of Piping System of Belmont, Mass.

To apply the method to plants in which pipes larger than 16-in. are involved some modification must be made, such as using the finest full line for 8-in. or even 12-in. pipe, representing the smaller sizes by dotted lines, or leaving them wholly out of consideration in outlining the supply system; or using double lines for the larger sizes of pipe.

## AN INVERTED SYPHON IN A SUCTION MAIN.

An inverted syphon installed in the collecting system of the water works of Boone, Ia., has been in use for over 5 years and no trouble attributable to this feature of the installation has been experienced. A description of the method employed in putting in this syphon was given by Mr. Karl C. Kastberg, City Engineer, Des Moines, Ia., the designer of the Boone plant, in a paper presented on Oct. 10 before the joint meeting of the Iowa and Illinois section of the American Water Works Association. Extracts from the paper follow:

Two distinct systems of screened wells connected to cast iron suction mains were installed. One system followed the east bank of the Des Moines River for a distance of approximately 2,000 ft., the wells being located in water bearing sand and gravel, connected to an 18-in. cast iron main, laid at a uniform grade of one-tenth of 1 per cent, beginning at an elevation of 2 ft. above low water and terminating at the common header of both lines, at an elevation of 4 ft. above low water.

This header together with the low lift pumps, is located in a concrete pit approximately 24 ft. in depth, and 300 ft. from the river bank.

The second system is located on an island in the river, which it traverses for a distance of 800 ft. Wells similar to those on the land system are connected to the pipe line, all being equipped with hermetically sealed concrete manholes as a measure of protection during stages of high water. The open channel between the island and the main land is 200 ft. in width, the bottom being approximately 12 ft. below the general level of the island.

The cast iron suction main was laid on a uniform grade beginning at an elevation of 1.60 ft. above low water and ascending through a distance of 800 ft. to a point opposite the water works station, to an elevation of 2.40 ft. above low water. The distance from this point to the pump pit in the station is approximately 550 ft.

An air chamber was provided by capping an 18x18x18 in. cast iron "tee" and dropping the main vertically to an elbow connection with the inverted syphon pipe under the east channel of the river. This pipe was laid to a carefully adjusted vertical curve to conform as much as possible with the general form of the river bottom.

A 2-in. galvanized iron pipe leading from the top of the air chamber, and carried down and parallel with the syphon pipe crosses the channel and is connected to a wet vacuum pump in the pit building. The syphon and air pipe were banded together and carefully lowered to place from a pile trestle bridge, and bedded 4 ft. below the channel bottom.

Flash boards attached to the top of the pipe during the process of lowering forced the water in the stream to flow under the pipe, eroding sand and gravel from below and materially expediting the operation of excavation for the pipe bed.

At low water stages the system at times operates under 16 to 18 in. vacuum, corresponding to approximately 20 ft. hydraulic suction.

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*Of Metcalf & Eddy, Consulting Engineers, Boston and Chicago.

## REPORT ON CAUSE AND REPAIR OF CRACKS IN WINNIPEG AQUEDUCT.

Certain defects having developed in portions of the aqueduct constructed in 1915 for the Greater Winnipeg Water District of Winnipeg, Man., the Administration Board of the District engaged the services of a special board of engineers to investigate and report upon the matter. This Special Board of Consulting Engineers consisted of H. N. Ruttan, Winnipeg, J. G. Sullivan, Winnipeg, and R. S. Lea, Montreal, Que. The report, extracts from which are given below, was submitted on Sept. 26.

The total length of aqueduct from the McPhillips Street reservoir to Shoal Lake is about 96.6 miles. The report deals only with 86 miles of line the greater portion of which is of the "flow line," "cut and cover" type. The standard depth of cover specified for the Shoal Lake Aqueduct is 4 ft. above the top of the arch. The minimum top width of the embankment is 8 ft. with side slopes of 1¾ to 1. The relative proportions of cut and embankment vary somewhat from point to point with minor irregularities in the surface, but the line has been so located that for miles at a stretch the surface slope is so uniform that the aqueduct practically parallels the surface without a break in grade. Between Mile 88 and Mile 96, where the line crosses the height of land west of Shoal Lake, the aqueduct is continuously in deep cut of from 12 to 22 ft., but here the upper part of the trench will not be refilled, so that the depth of cover will, in general, be restricted to four feet as in other portions of the line.

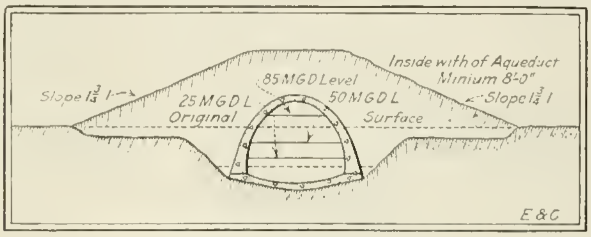

Fig. 1—Aqueduct Section.

'Figure 1 represents the particular section used at Mile 23, where the principal defects have occurred. The slope at this point is 0.30 ft. per 1,000, or 1.58 ft. per mile. The size is 8 ft. 9 in. x 7 ft. 4⅝ in. It is what is known as the "standard section" for cut and cover work in compact earth.

The aqueduct is built of 1:2:4 concrete of first class materials carefully selected and graded to form a strong and dense mixture. The invert is laid in alternate lengths of 15 ft. connected by a copper expansion joint, and the arch is built in lengths of 45 ft. with expansion joints of the same kind. The lengths of both invert and arch are built alternately and an entire length is poured in one operation. The inverts are first laid down for a considerable distance and then the arch is built upon them, the horizontal joint between invert and side-walls being provided with an effective water stop. Steel forms are used. The interior surface produced is very smooth and the concrete work in general is of high quality.

### Extent of Cracks.

The construction of the arch form of aqueduct was carried on at ten different points during 1915, and altogether 65,390 ft., or about 12.4 miles, was completed. In 13,380 ft. of this total length invert cracks have developed, usually a single crack along the middle of the invert but in a few cases, in badly cracked sections, at the side walls of the arch as well.

Close observation has been kept of these cracks from their first appearance, and by the use of "tell-tales" consisting of smooth pats of cement trowelled across the cracks any enlargement has been promptly detected and recorded. The last sign of movement was observed at the beginning of April, since which time there has been no indication that any further settlement has taken place.

In regard to the size of the cracks, these inverts may be grouped as follows:

In 4,815 ft. the cracks vary in width from 1/16 to ¼ in., and in a few cases slightly larger. A total of 4,017 ft. has cracks from 1/64 in. to 1/16 in. In the remainder, 5,193 ft., the cracks are merely hair cracks which can only be discovered by very careful examination. In many of the arches where the invert cracks are of any considerable size, corresponding cracks have occurred along the crown. In four arches where the backfilling was improperly done frost action has caused cracks along each haunch. A few arch cracks have been accidentally caused in removing the forms and small cracks have appeared due to temperature changes, etc., most of which had been formed before any load had been placed upon the arch.

About two-thirds of all the cracked inverts and nearly all the cracks above 1/16 in. in width were in miles 23 and 24 of Contract 30. The extent of the cracks in these two miles is as follows:

| | |
|---|---|
| MILE 23. | |
| Total length of aqueduct built | 13,930 ft. |
| Length of invert with cracks 1-16 in. to 5-16 in. in width | 4,305 ft. |
| Length of invert with cracks 1-64 in. to 1-16 in. in width | 1,620 ft. |
| Length of invert with hair cracks only | 225 ft. |
| MILE 24. | |
| Total length of aqueduct built | 7,405 ft. |
| Length of invert with cracks 1-64 in. to 1-16 in. in width | 390 ft. |
| Length with hair cracks only | 2,025 ft. |

### Cause of Cracks.

This work under Contract 30 is all in the "prairie section." The material is clay and at Mile 23, and where the cracks occur at Mile 24, the cut is shallow, generally between 1½ and 4 ft. in depth. The type of invert shown in Fig. 1, and referred to as the "standard invert for firm soil," was used.

The cracks formed at this point are much more extensive and much larger than in other portions of the work, and are practically continuous throughout the whole length at Mile 23. The bearing power of the material at this point has proved to be much less than was anticipated, and as a consequence the considerable settlement under the load as distributed by the type of invert used has resulted in the cracking of the invert and then of the arch as referred to above.

Partly in the way of experiment three arch lengths were underpinned with sand driven through holes in the invert close to the sidewalls before sufficient settlement had taken place to form cracks. These inverts have since stood without cracking, but the practice has not been continued.

Of the Mile 24 work, only a short length adjacent to the Mile 23 section has cracks of any size. This is partly to be accounted for by the fact that being on the steepest slope of the line the aqueduct cross section is the smallest; and while the type of invert used is the same as at Mile 23, the bearing area under the side-walls is relatively somewhat greater. The material is probably more compact as the slope is ascended and the undamaged portion is in a cut from 4 to 6 ft. in depth. Such cracks as have been formed have been caused as at Mile 23, by settlement.

The cost of the portion of the entire aqueduct structure in which the settlement cracks have occurred is $104,360. The cost of the invert alone is $34,198.

The damaged work can be repaired to be as permanent and efficient as other portions of the aqueduct. The Board of Engineers also are of the opinion that none of the work so far built will have to be removed.

### Method of Repairing.

In the Shoal Lake Aqueduct the cracks are, as explained previously, largely due to settlement, and when the invert has come to a permanent bearing and settlement has ceased there will be no further tendency for these cracks to open. The method of repair it is proposed to use, and which has already been used, is as follows:

The section to be repaired is thoroughly cleaned. The cracks are cut out to a depth of 1½ to 2 in. and to a width of about 1 in. This groove, as far as possible, is made wider at the bottom than at the top and never "V" shaped. It is carefully cleaned with water and then packed with neat cement slightly moistened and hammered solidly into place, using a special caulking tool. This makes not only an exceedingly tight joint, but a very strong one. Several sections of invert, including portions of these joints, have been cut out and tested. The cement filling, even after having been in place only two or three days, adheres so strongly to the concrete that when broken the break has generally been in the old concrete, sometimes in the filling, but never at the junction of the two.

Two sections of aqueduct at Mile 23, each about 270 ft. in length and purposely selected to include the most seriously damaged portion of the 1915 work, were repaired in this way in July last. Watertight bulkheads were built at each end of the sections, which were then filled with water to the level corresponding to the rated discharge of 85,000,000 gal. per day. Since then daily records have been kept of the loss of water as indicated by the fall in level, and are being continued.

The results so far are very satisfactory. The total loss at the present time is only about 250 gal. per day from each section, each of which has between 200 and 300 lineal feet of expansion joint below water level, and the quantity lost could escape through a single hole the size of a match. The result shows that the cracks have been very thoroughly closed. The loss of water stated is equivalent to less than 5,000 gal. per mile of aqueduct, which is much less than the limit usually specified in large concrete pipes under low heads.

The evidence furnished by a series of tests of portions of the completed aqueduct provided with special facilities for accurate observation of settlement, taken in connection with the fact that no settlement has taken place in the cracked sections since early in April, gives some indication that in most, if not all, of these sections, the aqueduct has come to a permanent bearing. There is plenty of time to obtain assurance of this and, until another year's experience is available, it would probably be advisable to restrict repair work to what may be required to secure such further information as may be considered necessary in the meantime.

The entire cost of the repairs described above, including labor, materials and incidentals, amounts to about 93 ct. per lineal foot of aqueduct. As the sections repaired are of large size and were cracked more seriously and extensively than other parts of the 1915 work, the average cost per foot of such repairs will no doubt be much less; so that even if much of it should have to be done over again, the total cost of repairing will probably not be very great.

### Recommendations for Future Construction.

The Board of Consulting Engineers in an interim report recommended that the construction of the aqueduct be proceeded with as on the following basis:

1. That on foundations of boulder clay, hardpan and gravel, the "Standard Section" be used, with the addition of extensions of the base on both sides.
2. That in foundations less firm than the above, the sections showing distributed load on the full width of the Aqueduct, D-317, be used. The projection of the foundation shown in the left of this section may be changed to 8 in., if the cost of excavation can thereby be reduced.
3. That the circular section as designed for laying which preparations are being made, be gone on with.

The first recommendation refers to the unreinforced type of invert illustrated in Fig. 1, but with 8-in. extensions on each side. It also restricts its use to the hardest foundations. The effect of the extensions is to reduce the maximum intensity of pressure on the foundation by about one-half.

This recommendation was made, notwithstanding the fact that nearly ten miles of the 1915 work with similar inverts, but without extensions, had stood without crack or other indication of undue settlement.

As a precautionary measure to provide against the uncertainties existing at the time, the second recommendation advised the use, in all of the compressible soils, of one of the heavy reinforced inverts designed by the Engineers, also with 8 in. extensions. This design has been used throughout the 1916 work except where the character of the foundation, in the judgment of the engineers, justified the use of the plain extended invert.

About fifteen miles of aqueduct has been constructed during the present season in accordance with these recommendations, and the greater part of it has been backfilled. So far no settlement cracks have developed in any of this work.

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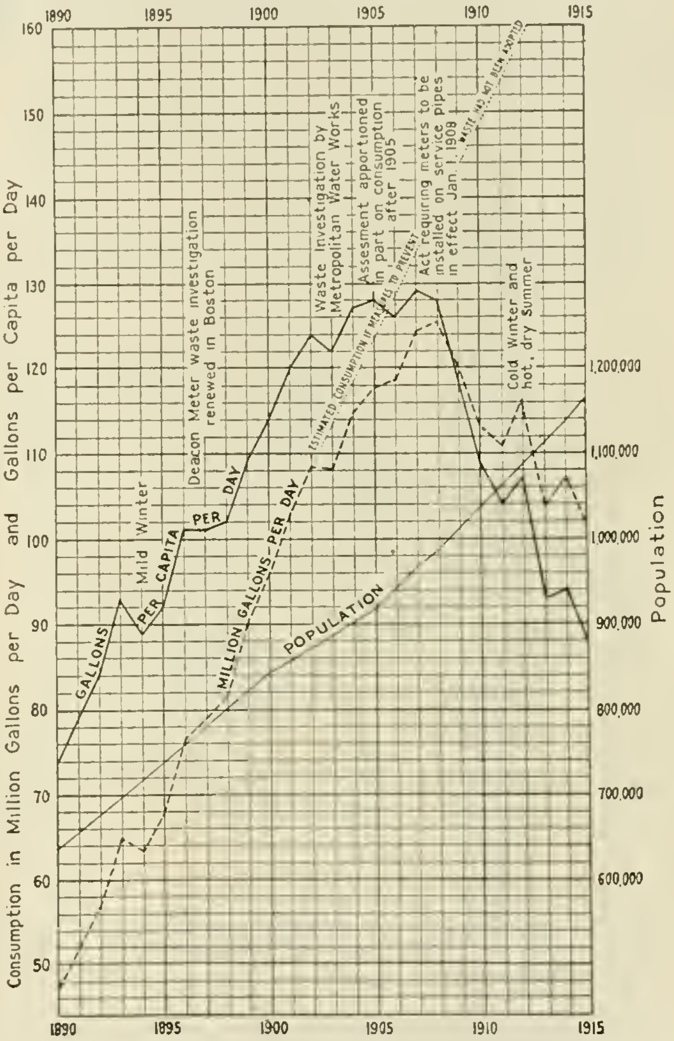
## WATER CONSUMPTION IN METROPOLITAN WATER DISTRICT, BOSTON, MASS.

The accompanying diagram reproduced from the recently issued report of the Metropolitan Water and Sewerage Board of Boston, Mass., for the year 1915, is of interest. It shows the per capita water consumption in the Metropolitan Water District from 1890 to 1915, and also indicates that the reduction in use of water due to the installation of water meters has resulted in saving more water than was required to supply the annual increase in population.



Population and Consumption of Water in Metropolitan Water District from 1890 to 1915.

The average consumption of water in the 18 municipalities supplied from the Metropolitan Water Works during 1915 as measured by the Metropolitan Water Works meters, was 101,941,500 gal. per day, which, on the basis of an estimated population of 1,164,600, is equivalent to 88 gal. per capita per day. The total consumption in each of the municipalities in 1915 was less than in 1914, with the exceptions of the city of Malden and the town of Watertown, and the per capita consumption was less in 1915 than in 1914 in all of the municipalities, with the exception that there was no change in the per capita consumption in Malden and Watertown. The consumption in the municipalities supplied was 5,094,600 gal. per day less in 1915 than in 1914, or 4.76 per cent less than the 1914 consumption. This was probably due in large measure to climatic conditions, as there was no long period of extremely cold weather or of extremely hot dry weather during 1915, which would cause the consumption to be larger than usual.

## SOME DESIGN FEATURES OF THE 3,500,000-GAL. REINFORCED CONCRETE RESERVOIRS FOR LANSING, MICH.

The city of Lansing, Mich., awarded contracts last week for the construction of two reinforced concrete reservoirs that involve a number of interesting structural features. Each reservoir will have a capacity of 3,510,000 gal., will be circular in plan, with an inside diameter of 155 ft., and will have a roof supported on the wall and columns. This roof will be covered with earth. The approximate quantities include the following:

| | |
|---|---|
| Earth excavation, cu. yd. | 17,000 |
| Concrete, footings of wall and columns, cu. yd. | 255 |
| Concrete, floor, cu. yd. | 295 |
| Concrete, walls, cu. yd. | 547 |
| Concrete, columns and capitals, cu. yd. | 180 |
| Concrete, roof and cornice, cu. yd. | 451 |
| Concrete, parapet wall, cu. yd. | 18 |
| Reinforcing steel, lb. | 645,000 |
| Structural steel, lb. | 17,700 |

The roof will be of the fiat slab design and is covered by the Norcross patent. The total area of roof slab is approximately 39,000 sq. ft.

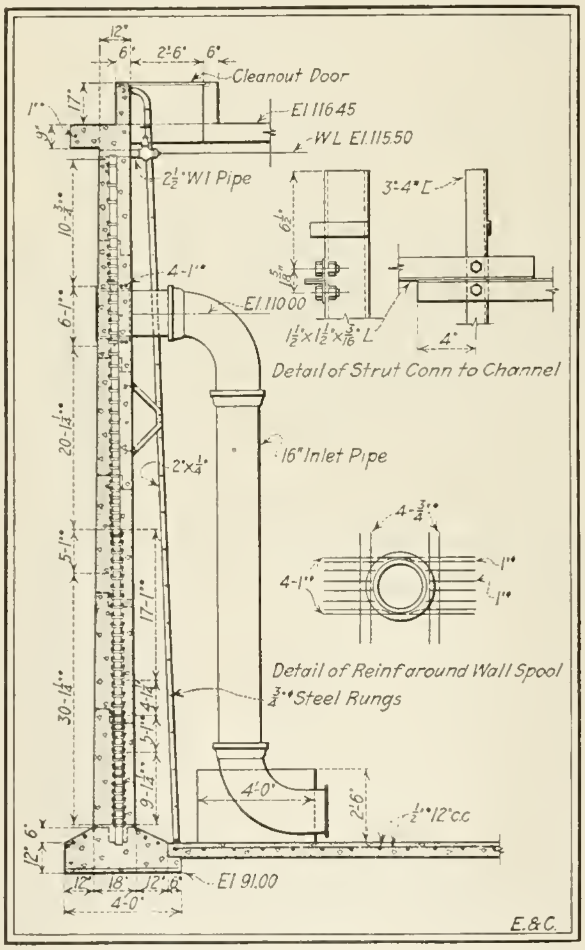


Fig. 1—Section of Wall of Lansing Reservoir.

The walls will be 12 in. thick at the top and 18 in. thick at the bottom. A vertical section of the wall is shown in Fig. 1. The wall reinforcing bars will be fastened to steel channels, of which there will be 60 in each reservoir. These channels will be spaced equally around the circumference 8 ft. 2⅛ in. center to center and will have their upper ends joined by means of 1½ in. x 1½ in. x 3/16 in. L's. The lower ends will be embedded in the concrete footing of the wall.

The concrete for the wall will be placed in horizontal courses extending entirely around the circumference and not more than 4 ft. in height. The joint between each course and the next one above it will have a 6-in. step, the upper surface of the outer portion of the course being that much higher than the upper surface of its inner portion. In the lower portion of the wall, where there are two vertical rows of horizontal reinforcing bars, this 6-in. vertical step will come just outside of the outer row of the bars. In the upper part of the wall, where there is only one row of bars, the 6-in. vertical step will come just inside the steel channels.

The specifications require that just before the work of pouring any layer of concrete is begun, the abutting surface of the underlying old work shall be thoroughly cleaned, and scratched with a stiff wire brush, every particle of dirt, dust, dead mortar, or other rubbish being removed, a vacuum cleaner with suitable suction nozzle being finally used to remove the finest particles. The surface will then be sprinkled with water, and cream of neat cement shall be spread over and thoroughly brushed into the moistened surface. The new concrete will be poured immediately after the application of this cream of neat cement.

The expansion joints will be made where the floor rests upon and abuts against the footings of columns and of wall. After the footings are placed, and just before the floor is laid up to any footing, the surfaces against which the floor is to rest will be covered with an elastic waterproof membrane composed of alternate layers of a coal tar mixture and of roofing felt. The specifications regarding this include the following clauses:

The coal tar mixture will be composed of coal tar and of coal tar pitch, properly and thoroughly mixed while hot at such temperatures and in such proportions as may be from time to time directed by the engineer on the ground. The roofing felt will be the best quality Barrett roofing felt, weighing approximately 15 lb. per 100 sq. ft., or other equally good felt, to be first approved by the engineer.

All projecting lumps in the surfaces of the concrete to be covered must be smoothed off, and all depressions that might cause stretching of the waterproofing materials must be filled with cement mortar to a smooth and even surface; and all of the said surfaces must be carefully cleaned and left perfectly dry and free from all dust and litter immediately before applying the waterproofing materials.

The coal tar and coal tar pitch will be cut into slabs or pieces of convenient size, and, mixed in the proper proportion, will be heated in a regular asphalt heating kettle until the mixture is of such a consistency that it will run quickly, like oil, off a stick. This temperature not only gives the best results in the way of filling the pores in the surface, but also gives the greatest covering capacity. Whenever the mixture in the mopping bucket begins to cool and thicken, it will be poured back into the kettle, and a fresh bucketful obtained from the kettle.

The mops for applying the mixture should be regular roofing mops. Work will be carried on continuously from the place at which the mopping is begun, not over 1 yd. at a time being mopped in advance of the felt, which should be quickly rolled down into the mixture. Always swab the compound on crosswise the full width of the sheet.

The felt must be rolled into the mixture immediately after the mop, the roll to follow the mop just as closely as possible. As soon as the felt is rolled into the hot mixture, the felt must be thoroughly rubbed and pressed over its entire surface, from the middle of the sheet forward and outward to each side, so as to insure the thorough sticking of the felt over its entire surface, and prevent the formation of air pockets.

The men applying the felt should wear heavy cotton gloves, so as to enable them properly to rub the felt into the hot mixture at all points. The hot mixture makes the felt very flexible, so that it can be easily formed and pressed into and around any corners. Heat in the compound, and quickness and thoroughness in rolling and pressing the felt into it in the proper directions, are the essential points to be observed. When more than one layer of felt is to be laid, the edges of the sheets need not lap, but should be butted close together.

Over the entire surfaces of the expansion joints, place alternate layers as follows: First, a layer of coal tar mixture; second, a layer of the felt; third, a layer of the coal tar mixture; fourth, a layer of the felt; fifth, a layer of the coal tar mixture. The laying of the portion of the floor which is to rest against any expansion joint will follow immediately after the application of the fifth layer specified above.

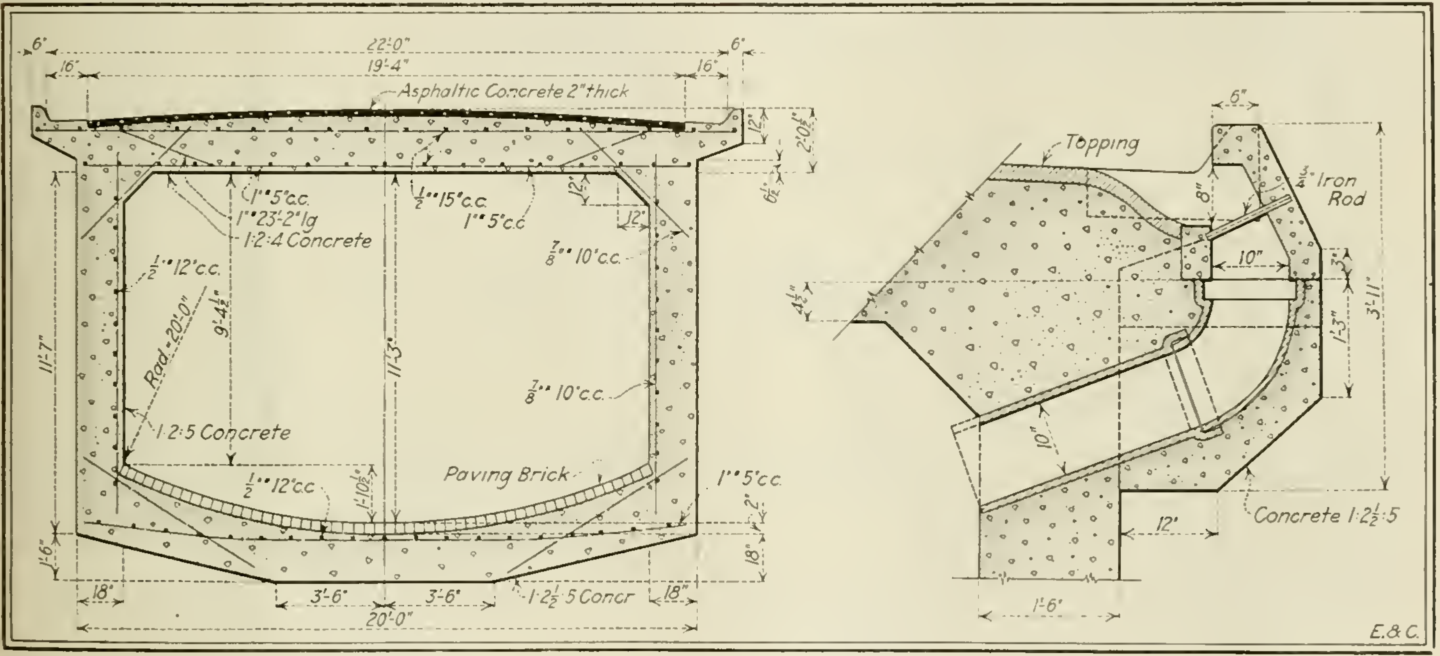
Bids for the construction of the two reservoirs were received Nov. 1 by Guy R. Crane, manager, Water and Electric Light Department of Lansing, Mich. The bidders and their bids were as follows:

| | |
|---|---|
| Armstrong Engineering Co., Taylorville, Ill. | $ 73,683 |
| Larson-Danielson Constr. Co., LaPorte, Ind. | 75,850 |
| L. J. Mensch, 138 N. La Salle St., Chicago, Ill. | 77,350 |
| Leyden-Ortseifen Co., Monadnock Bldg., Chicago, Ill. | 84,725 |
| F. H. Pitkin, 710 Boulevard Bldg., Chicago, Ill. | 95,000 |
| R. H. Folwell, 2051 McCormick Bldg., Chicago, Ill. | 97,000 |
| Wm. H. Carter Constr. Co., 2643 W. Monroe St., Chicago, Ill. | 113,577 |
| Benjamin Douglas Co., Ann Arbor, Mich. | 128,000 |
| Albert H. Prange, Grand Rapids, Mich. | 138,000 |

The contract was awarded to the low bidder. The reservoirs were designed by Dabney H. Maury, consulting engineer, Chicago, Ill.

## COMBINATION SEWER AND STREET PAVEMENT BASE.

A storm sewer constructed recently in Minne Lusa Ave., Omaha, Neb., is so designed that the reinforced concrete slab top of the sewer serves as a base for the street pavement carrying the traffic on the avenue. The arrangement is shown in the accompanying illustration, which also contains a sketch of the curb inlet. The sewer extends from Redick Ave. to a point 60 ft. south of Newport Ave., and required the following approximate quantities: 280 lin. ft., 11 ft. 3 in. by 17 ft. reinforced concrete sewer and 550 ft. of 11 ft. 3 in by 17 ft. brick and reinforced concret sewer. The latter type has a concrete invert lined with 1-course of paving block and 18-in. brick walls. Bars ¾-in. square, 3 ft. long and with a piece of ¾-in. square bar 6-in. long at each end, are placed 18-in. centers in the brick wall and extend up into the reinforced concrete slab top. The pavement consists of a topping of 2-in. asphaltic concrete. The concrete in the side walls and the bottom is a 1:2½:5 mix; in the top it is a 1:2:3 mix. The plans were prepared under the supervision of John A. Bruce, City Engineer, Omaha, Neb.



Section of Minne Lusa Ave. Storm Sewer and Curb Inlet.

## SNOW DISPOSAL THROUGH SEWERS.

An interesting plan for disposing of snow through sewers was tried out last winter by Mr. H. S. Richards, Superintendent of Maintenance and Repair, South Park Commissioners, Chicago. A device consisting of a water turbine armed with three free blades and mounted in a wire cage or basket was set in a sewer manhole. The turbine was connected with a fire hydrant, the stream of water flowing through the basket into the sewer. The free blades on the turbine agitated the snow shoveled into the basket and mixed it with the water which carried it on through the sewer. In a paper presented at the recent convention of the American Society of Municipal Improvements, Mr. Richards states that with a pressure of 15 lb. to 25 lb. the machine disposed of all the snow that two men could shovel into the basket, and with a higher pressure it should take care of all that four men could shovel into it.

## DETERMINING AMOUNT OF FILTERED WATER TO BE WASTED AFTER WASHING.

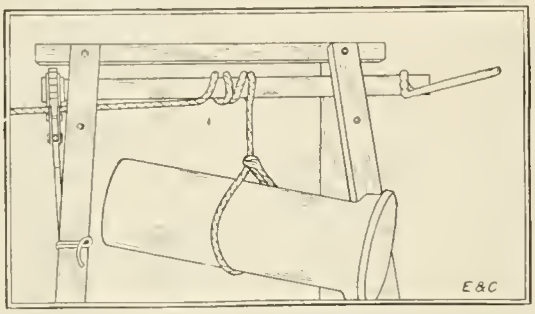
When the Chain of Rocks filter plant of St. Louis, Mo., was first put in operation in the spring of 1915 several problems required experimental solution. One of these was the determination of how much filtered water should be wasted after washing. The following description of how this was done is taken from the report of G. G. Black, Engineer in charge: Tests were made in May to determine how much water would be wasted per minute for each inch of opening of the waste water valve under working conditions and with the valve wide open. The rate was over 8,000,000 gal. per day. The turbidity of the effluent was measured every three minutes at various rates of filtration without wasting any of the effluent, and it was found that the 500,000-gal. rate, the lowest at which it was possible to control, gave the best results. Running at this rate the first effluent was clear, became turbid for a time, and then became clear again. A probable average was 5,000 gal. of clear water and over 18,000 turbid. Dry aluminum sulphate was added to the water in the central gutter when filling the bed after washing; one, two and three grains per gallon for the quantity of water above the sand amounting to 7 lb., 14 lb. and 21 lb. per bed were tried, and 14 lb. gave the best result. Adding 14 lb. after washing, the turbidity during the turbid period seldom exceeds 1 part per 1,000,000 and is often as low as ¼ part per 1,000,000, the average amount of effluent running clear immediately after washing being about 4,500 gal., and the turbid amount equaling 11,000 gal. The time after washing until running clear varied from 40 to 50 minutes, and after this time the rate could be raised to any amount up to 5,000,000 gal. daily, the highest rate run up to this time, the effluent remaining clear. The immediate increase in the loss of head, after raising the rate, varied from 1ft. to 3.5 ft.

As a result of these experiments, 14 lb. of dry aluminum sulphate is put in the central gutter, as the bed is filling after washing, no effluent is wasted and the filter is run for one hour at the 500,000-gal. rate and then raised to the required rate.

## PIPE LAYING APPLIANCE.

The Pacific Gas & Electric Co. is using the arrangement shown in the accompanying sketch for laying pipe up to 16 in. in diameter. The appliance consists of a wooden trestle supporting a windlass pipe turning on wooden bearings by means of a pipe chain tongs. A ratchet screwed to the pipe and fastened to one leg of the trestle prevents reverse motion.

The method of operating is as follows: A rope is fastened to the pipe or fitting and the free end wrapped four times around the windless pipe. One man handles the chain tongs and another takes in the slack rope, the ratchet meanwhile taking care of the slip. The lowering is accomplished by the one man easing up on the rope. The device was described by Mr. G. E. Keppelmann, Superintendent of the Gas Distributing Department of the Pacific Gas & Electric Co., in a paper presented to the recent convention of the Pacific Coast Gas Association.



Pipe Laying Device.

## COST OF METER MAINTENANCE AND REPAIR AT CHICAGO.

The average cost of meter maintenance in Chicago in 1915 was $3.44 per meter, a decrease of 13 cts. over the figures for the previous year. Several hundred new meters were used last year to replace old worn-out meters in service. The cost of new meters used is included in the maintenance cost. The average cost of maintenance per meter has steadily decreased. In 1909 it was $6.03; 1910, $5.26; 1911, $4.73; 1912, $4.45, and 1913, $3.97. These figures are given in the report on the water meter shops in the recently issued report of the Chicago Department of Public Works. The following figures show some of the work carried out last year by the branch:

During 1915, with an average monthly force of 47.55 employes in office, shop and field, there were performed 36,209 jobs of repairs, replacements and installations of water meters at a cost of $50,092 for mechanics, motor truck drivers, laborers and team hire; $11,539.25 for supervision and clerk hire; a total cost of $61,631.69 and $49,692.26 for meters, meter parts and material. As a reimbursement for expenditures made for overtime work and installation of emergency and fire meters, etc., there were billed to consumers the amount of $3,559.68. (See table No. 3.)

There were 1,250 meters installed during the year and 235 permanent removals. The total number of meters in service Dec. 31, 1915, was 19,489, as compared to 18,474 at the close of 1914; an increase of 1,015 in service.

During the year 784 emergency jobs were taken care of at a cost of $1,154.08; an average of $1.47 per job; 530 of these jobs were completed on the first visit; 254 were repaired temporarily and a second visit was necessary to complete the job. The greater part of these emergency jobs were due to meters filling up with sand, fish and other substances and required immediate attention. During the year 6,203 meters of the ⅝-in. to 2-in. size inclusive were purchased on contract.

Table I shows the rate of wages paid the employes of the water shop branch, and Table II gives a recapitulation of the number of jobs performed and cost of labor and material used in repairs, replacements, and construction and betterments of water meters. Table III gives some details of the shop work.

TABLE I.—SALARIES.

| Position. | Rate. | Cost of labor for repairs and replacements. | Cost of labor for construction and betterments. | M'thly av'ge No. of men employed. |
|---|---|---|---|---|
| General meter foreman | $2,520 per year | $ 2,235 | $ 285 | 1 |
| Assistant general meter foreman | 1,800 " " | 1,596 | 203 | 1 |
| Meter shop foreman | 1,800 " " | 1,596 | 203 | 1 |
| Senior clerk | 1,400 " " | 1,277 | 162 | 1 |
| Junior clerk | 1,200 " " | 1,064 | 135 | 1 |
| Junior clerk | 960 " " | 982 | 125 | 1.15 |
| Junior clerk | 840 " " | 630 | 80 | .85 |
| Junior stenographer | 960 " " | 851 | 108 | 1 |
| Motor truck drivers | 960 " " | 831 | 250 | 1.13 |
| Machinists | $5.50 per day | 3,858 | 785 | 3.07 |
| Meter setters | 5.50 " " | 23,612 | 2,821 | 17.50 |
| Meter tester | 5.20 " " | 1,050 | 131 | .88 |
| Laborers | 3.00 " " | 8,547 | 1,212 | 11.85 |
| Teams | 4.50 " " | 6,071 | 919 | 5.12 |
| | | $54,205 | $7,425 | 47.55 |
| Supervision and clerical | | | | $11,539.25 |
| Mechanics, motor truck drivers, laborers and team hire | | | | 50,092.44 |
| Total | | | | $61,631.69 |

The above monthly averages are based on 274.5 actual working days in 1915 for machinists, meter setters, and laborers, and 303 days for teams.

TABLE II.—REPAIRS AND REPLACEMENTS—FIELD WORK.

| Description of work performed. | No. of jobs. | Labor cost. | Material cost. | Av. cost per job. |
|---|---|---|---|---|
| Investigations | 1,499 | $ 1,569 | ....... | $1.04 |
| Meters removed permanently | 235 | 355 | $ 4 | 1.53 |
| Meters repaired on premises | 5,892 | 8,127 | 523 | 1.47 |
| Meter locations changed | 5 | 21 | 6 | 5.61 |
| Meters placed | 1,149 | 9.229 | 1,759 | 2.65 |
| Leaks repaired | 127 | 195 | 30 | 1.78 |
| Meters removed for safekeeping | 154 | 279 | ....... | 1.82 |
| Fish traps installed | 18 | 176 | 348 | 29.20 |
| Check valves installed | 1 | 12 | 6 | 18.17 |
| Cost of 530 new meters used for replacements | ...... | ....... | 8,289 | ..... |
| Maintenance of two auto trucks, 7 months | ...... | ....... | 368 | ..... |
| Supervision and clerk hire | ...... | 4,605 | ....... | ..... |
| Totals | 12,080 | $24,573 | $11,336 | $2.97 |

TABLE III.—SHOPWORK.

| Description of work performed. | No. of jobs. | Labor cost. | Material cost. | Av. cost per job. |
|---|---|---|---|---|
| Meters tested before repairs | 811 | $ 357 | ....... | $0.44 |
| Meters tested and sealed after repairs | 3,513 | 1,434 | $ 91 | .43 |
| Meters repaired in shop | 3.523 | 12,445 | 2,660 | 4.29 |
| Meter parts rehabilitated | 6,288 | 2.389 | 238 | .41 |
| Material rehabilitated | 3,991 | 84 | ....... | .02 |
| Repairs and replacements to building and apparatus | ...... | 399 | 12 | ..... |
| General work | ...... | 5,253 | ....... | ..... |
| Supervision and clerk hire | ...... | 5,628 | ....... | ..... |
| Totals | 18,126 | $27,993 | $3.002 | $1.71 |

An indication of the widespread interest in engineering circles as to our future commercial and engineering relations with South American countries is given by the fact that 180 out of 231 students entering Stevens Institute of Technology this fall have elected to study Spanish instead of French or German. This is a most remarkable increase in proportion over other years at Stevens in favor of Spanish.

## PERSONALS.

Folsom & Taylor, civil engineers, have opened an office at Room 704, People's Bank building, Bloomington, Ill.

George B. Gascoigne, heretofore assistant engineer in the City Engineer's Department of Cleveland, O., has been appointed Sanitary Engineer of that city.

John Sherman, for several years engineer in the employ of the U. S. Reclamation Service at Ellensburg, Wash., has accepted a position as engineer with the Braden Copper Co. project at Rancagua, Chile.

Alfred D. Flinn, deputy chief engineer of the Board of Water Supply of New York City, has been appointed secretary of Mayor's Advisory Committee on the extension courses at the College of the City of New York for municipal employes.

S. B. Williamson, heretofore chief of the field forces of the Guggenheim interests, has been appointed construction engineer. His headquarters will continue to be in New York City. Mr. Williamson formerly was chief of construction for the U. S. Reclamation Service.

## INDUSTRIAL NOTES.

The businesses of the Buffalo Steam Roller Co. and the Kelly-Springfield Road Roller Co. have been merged. The new company will be known as the Buffalo-Springfield Roller Co. Its main factory will be located at Springfield, O., with the home offices at the same place. The consolidated company will, it is stated, constitute the largest concern in the world engaged exclusively in the manufacture and sale of road rollers. The line of manufacture will comprise rollers of all types for all purposes and in sizes varying from 2½ tons to 20 tons, including the full line of Buffalo Pitts rollers in both the tandem and macadam types, as well as the complete line of Kelly-Springfield steam and gasoline rollers in both the tandem and macadam types. The entire sales organization of the Buffalo Steam Roller Co. will be taken over by the new company, and the present branch offices of the Buffalo Steam Roller Co. located at Boston, New York, Philadelphia, Pittsburgh, Chicago and Portland, Ore., will be continued as branches of the new company.

Excavation and Railways Monthly Issue
of
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Halbert P. Gillette, *President and Editor*

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## WHAT IS THE INCREASED LABOR COST OF NIGHT WORK?

Double and triple-shift work is so common that it is rather astonishing to find almost no data in print relative to the comparative efficiencies of day and night shifts. One of our contempararies not long ago sought to secure data on this question, but with little success. The few readers who replied dealt almost entirely with generalities.

Mr. W. Michel, chief engineer of the Chesapeake & Ohio Northern Ry., stated that in filling trestles with gumbo, hauled several miles in trains, the night gangs on the shovel and trains averaged about 75 per cent as great a yardage as the day gangs.

Mr. H. B. Whitney, a contractor of Emmetsburg, Ia., states that on drainage work (using a 1-yd. dredge), where kerosene lamps and torches were used, night work was about 80 per cent as efficient as day work. In harbor dredging, where there was less wind at night, the night gang usually dredged slightly more than the day gang.

It has long been generally recognized that where the plant investment is small and the wage item is high, it rarely pays to work at night, save for the purpose of completing a job within a time limit.

In hauling materials with motor trucks, many contractors find it profitable to work the trucks at night under certain conditions, particularly where the haul is long. Except over bad roads, a motor truck can safely travel almost as fast at night as during the day time.

Have any of our readers definite knowledge as to the efficiency of night motor trucking? Information on this or, indeed, on any other class of night work will be a welcome addition to our growing knowledge of unit costs.

## THE EFFICIENCY OF WORKMEN.

"Know then thyself, presume not God to scan; the proper study of mankind is man."

It is two centuries since Pope wrote this couplet, yet how meager does man's study of himself remain. Taking only, for example, man's efficiency as a muscular machine, how little is known of the conditions under which his greatest efficiency is attainable. The 8-hour day would speedily receive not only "the sanction of society" but immediate enforcement industrially were it definitely known that more work can ordinarily be accomplished in eight hours than in nine or ten. But where is the proof?

The consensus of opinion is that where hard muscular effort is involved, a man can, if he is willing, perform more work in eight hours than in ten. But "opinion" is often wrong even where unanimous. Who really knows? This is a question of vast importance, but where are the actual tests upon which to base an answer?

If an 8-hour day is more effective than a 10-hour day, is it certain that a 7-hour day is not still better? Where are the tests?

Intermittent muscular work is claimed by many men to be more effective than continuous work. In driving a tunnel in Mexico it was determined many years ago that greater progress could be secured by working two hours, resting two hours, and so on until each man had worked six hours. Mexicans, however, lack the endurance of Americans, under heavy exertion, and it is likely that a different time schedule would be necessary for an American than for a Mexican. Negroes are also said to be more effective where the work is decidedly intermittent. But where are the tests?

Carniverous animals are not capable of long-sustained effort to the same degree as herbiverous animals. Diet may, and probably does, affect men in a similar manner. But where are the tests?

Engineers who would not think of discussing the relative efficiency of machines without test data thereon, will often argue by the hour about the efficiency of workmen, and yet be unable to produce any labor tests at all, unless by courtesy we concede that opinions "based on long observation" merit the title.

Economic problems can never be accurately solved in the absence of quantities secured by observation. Figures may not lie, and liars may figure, but no economic truth can be established in the absence of figures. We need cost data on every economic problem, and we can solve no economic problem unless cost data are available. Costs may be directly expressed in money or they may be indirectly expressed in quantities of labor or the products of labor, but we must have cost data or their functions before we can definitely answer any economic problem.

All this is self-evident, one may say, but isn't it curious that self-evident generalizations remain so long unappreciated? Isn't it strange that amid all our knowledge of ourselves, we know so little about our own muscular and nervous powers that we cannot answer definitely some of the simplest questions about the efficiency of workmen?

## LET US HAVE AN ANNUAL EXCAVATING MACHINERY SHOW.

The continued success of the annual "Cement Show" should serve to arouse among manufacturers of earth and rock excavating and transporting machinery a determination to give an annual Excavating Machinery Show. America easily leads the world in the production of devices for loosening, loading and transporting earth and rock. To name but a few of the "dirt moving" inventions developed in this country will suffice to indicate the debt of the world to American ingenuity.

Among the earliest and simplest of earth moving devices accredited to an American is the wheeled scraper. Almost contemporary with it was the invention of the hydraulic giant, first used by a California placer miner. And but a little later came the first successful rock drill. Then followed the suction or hydraulic dredge. The "elevating grader," the "road machine," the "patent dump wagon," the "caterpillar tractor," the "gang plow," the "car unloading plow," the "drag line scraper," the "pneumatic hammer drill," the "cable drill," the "rock channeler," the "power drill sharpener," the "rotary steam shovel," form a list of inventions that would alone give leadership to Americans in the field of "dirt moving." But these are not all, nor do they include methods of excavation, such, for example, as "chamber blasting," which are as ingenious as the tools employed. There are, moreover, almost numberless improvements on older machines, and some of these improvements have become as important as the original invention to which they relate.

The drag or slip scraper has been attributed to America. Certain, at any rate, is the fact that it is seen everywhere in this country and almost nowhere in Europe. As an evolution of the "slip," the Fresno scraper—a California invention—is superior to the old slip scraper for most purposes; but, old though the Fresno is, it is rarely seen east of the Mississippi Valley. And this brings us to one of the reasons why an Excavation Show is desirable.

Men may read for years about this or that machine, and hesitate to try it; but when they see the machine, particularly when it is at work, the same men are speedily converted to its use. If, then, a representative collection of excavating machines were displayed at work once a year in a centrally located city like Chicago, and if the show were widely advertised to contractors and engineers, we doubt not that its educational effect would be great.

Why not hold such a show in Chicago during the week immediately following the Cement Show, in February? It could be combined, perhaps, with a display of mining machinery, for "dirt movers" and mining men are interested in much the same classes of machinery.

Is it too late for manufacturers to organize and prepare for an Excavation Show next February? We trust not, but if three months does not give sufficient time for adequate preparation, let it be resolved to organize now for the Excavation Show in 1918.

## MOTOR TRUCKS OPERATED ON TEMPORARY RAILWAYS.

There undoubtedly are conditions where a contractor should lay a temporary track rather than build a temporary road for motor trucks to operate upon, although we have yet to hear of this being done. Old pleasure automobiles are being operated in place of trolley cars on a number of suburban railway lines, and motor trucks have been operated on permanent steam railway tracks, but we are speaking now of a somewhat different matter.

In wet weather it is frequently impossible to operate a motor truck profitably over a poor clay road. The truck will skid unless tire chains are used, and these cut the tires to pieces. When such a condition arises and there is much trucking to be done, it may pay to lay a temporary railway, using second-hand rails. Probably wooden stringers shod with angle iron would be cheaper in some cases. In either case, flanged wheels would be used on the truck and its trailers.

If only one or two very steep, short grades are to be surmounted, a hoisting engine can be used to "snatch" the truck up and to "snub" it back down the hill.

Simply because a motor truck can be made to travel over almost any sort of road, let it not be supposed that a railway track is never to be used where motor trucks are available.

Field railways for small locomotives and cars are extensively used along the battle lines in Europe. To make the track readily portable, the rails are cut in 4-ft. lengths, and a pair of rails is bolted to a cross-tie at one end, and at the other end a steel tie rod holds the two rails in position. One man can carry and lay such a track "unit." The scheme is suggestive of what may be done in building a temporary railway line for motor trucking.

## WET WEATHER ADVICE TO INEXPERIENCED "DIRT MOVERS."

Many a dirt moving contract hums along profitably during the summer and early fall, only to end in financial disaster after the autumn rains start in earnest. It took several bitter experiences to teach the writer that it pays to shut down grading work before the fills have become quagmires, unless the time limit enforces continuance regardless of cost. In that case, a contractor should seriously consider the use of railway track and dump cars even though the amount of earth to be moved is relatively small. For the wet weather job the use of a light portable track and small cars has proved a life saver for many a grading contractor.

Where the amount of dirt to be moved was small and the distance short, the writer has frequently used "pole tracks," and in several cases he has used "skid tracks," over which loads were hauled in "boats" that slid on the greased wood.

A "pole track" consists of rails made of small round poles bedded in the ground so as to form a sort of wooden railway over which a box loaded with earth or rock is dragged.

A "skid track" consists of wooden cross-ties bedded in the earth, but without any rails. A long sled with wooden runners (about three times as long as the cross-ties are spaced) can be hauled over the greased cross-ties, or "skids," in a manner that is surprisingly effective. In fact, if there is a slight down-grade in favor of the load, a team can pull a greater load in this manner than in a wagon over a fairly good dirt road.

It would pay many a dirt mover to spend a week in a logging camp where "skid roads" are used. In this connection we may add that the loggers can teach us several tricks in the use of donkey engines and wire rope. The long distance that they move big logs in this manner, in the face of many obstructions, will surprise any man who has not seen them do it.

The "log chute" is another contrivance that merits seeing, not because it can be often used by a contractor, but because it shows what resourcefulness will accomplish even in the absence of appliances except of the simplest sort. A "log chute" is a crude trough laid on a hillside, and kept greased so that a log will toboggan its way to the valley below. Keeping the chutes greased is a job that occasionally requires something more than a man, a bucket of "dope" and a swab, for black bears and grizzlies have a fondness for grease in winter time that makes them indifferent to the fiercest looking "greaser."

One old-time "greaser" told the writer that he didn't mind feeding a bear a fair share of the "dope" every day, but when the bear went off and brought back four relatives that ate all the grease as fast as he swabbed it on the chute—then he decided it time to show that he was peeved. So he placed a large log, which he sharpened at the bow end alongside the chute and started work. Soon he heard the snuffling of the bears—also at work—behind him. Then he dumped the entire grease pail into the chute, to hold them for awhile, and climbed up the hill to the log torpedo, which was speedily launched.

"How did it work?"

"Work! Say, the old grizzly grandad of 'em all is working for me yet. I got his skin to home for a mat. Ye see, he stood his ground, as a grizzly will, opened his old jaws about two foot when he seen the log coming, and in course it went right on, as a log in a chute will, turned him inside out and left his pelt stretched on the log as neat as a glove on a finger. I most fergot to say the skin was tanned by rubbing on the hemlock bark as the log skidded the rest of the way to the bottom of the hill."

Some hill, some log, some bear, and some "greaser."

## "EAST CLEVELAND COMMISSIONERS TO CHOOSE CIVIL ENGINEER TO DIRECT TOWN."

This caption is taken from the headlines of the Cleveland (Ohio) "Plain Dealer." East Cleveland, a suburb of Cleveland, but itself a city of nearly 25,000, has elected five city commissioners who are to select a city manager to take office about a year hence, Jan. 1, 1918.

The commissioners are all business men of Cleveland. One of them, Mr. E. M. Sprague, is manager of the Cleveland branch of the American Bridge Co. Another one, T. P. Cagwin, was formerly commercial superintendent of the Cleveland Telephone Co. A third one, Mr. W. M. Pattison, is president of a company dealing in railway and mill supplies. The remaining commissioners, Mr. A. W. Calder and Mr. A. T. Hopkins, are also in business. It is significant of the changing attitude in municipal affairs that these five business men were induced by a new charter association to run for the commissionership.

The city manager, who is to assume the duties of mayor and director of public service, is to be an engineer, preferably one who has worked under one of the city managers in Dayton, Springfield, Sandusky, Ashtabula, Cadillac, Niagara Falls, Wheeling or Norfolk. His salary will be at least $3,600 and it may be made as high as $4,500 a year.

The "city manager movement" will undoubtedly find increasing favor, so long as the policy of selecting engineers as managers is adhered to. Civil engineers who plan to become city managers will do well to consider the advisability of securing positions under engineers who are already managers of cities, for other towns are likely to follow the lead of East Cleveland in giving preference to engineers who have been identified with this form of municipal government.

The future for civil engineers in this line of executive engineering is dependent entirely upon the success of the engineers who now enter it. Let us hope, therefore, that few cities will err in the selection of their managers. It should be realized that a city manager should be both an engineer and an executive, a man scientifically trained and at the same time possessed of native ability and experience in managing men.

## "WHY DO NOT ALL ENGINEERING COLLEGES DEVELOP READING HABITS?"

To the Editor: In discussing the editorial printed in Engineering and Contracting of Sept. 20 entitled, "Why Do Not All Engineering Colleges Develop Reading Habits?" the writer would change the title to "Why Do Not All Engineers Develop Reading Habits?" For the former implies that the college and not the graduate is to blame. The writer will discuss the question on the basis of "Why engineering students are not properly started in engineering reading," and, second, "Why a young graduate does not keep up reading habits even though required as an undergraduate."

One reason that more attention is not paid to current engineering literature in many engineering colleges is that the curriculum is very much crowded for the present 4-year professional course. In the early years of the course the student has not experience enough to appreciate an engineering article and with difficult studies and a crowded program of work, reading becomes recreation. On this account current fiction naturally attracts the young man. At the same time the student's English work is largely a study of standard English literature and no connection is shown between professional articles and good English. A second consideration is that the constant flow of new text-books with frequent revisions and the steady improvements of the engineering hand-books encourages reference to such works rather than going directly to engineering magazines. Misleading titles, the lack of adequate instruction in the use of the engineering magazines together with poor indexing in most school libraries discourages direct reference to the periodicals in design and similar courses.

I think the failure of the engineer to read systematically in the early years after graduation is due to a great extent to lack of time. The average young engineer puts in a hard day's work and leaves the office tired out. Any reading that he does must be on his own time and almost necessarily in the evenings. Second, I believe many times the wrong attitude is taken to engineering literature by some employers, who preach to young engineers, "Now forget your book knowledge and learn practice." The young graduate does not always realize that theory goes hand in hand with practice. A third consideration is that engineering today is largely specialized, and as the young man gradually masters his particular line he finds that much which is written is not new or worth while. The further fault in many periodicals, that it is necessary to read an article to discover its nature, dampens regular reading habits. As a young engineer grows older social duties and necessity for relaxation because of added responsibility tends again to break up the reading of engineering literature.

To increase systematic reading by engineers the following suggestions are made:

1. Before graduation. (a) Do not let the student specialize too early in his course and give definite reading assignments in shop and drawing courses to acquaint him with engineering periodicals. It is even desirable to refer him to popular and semi-popular engineering papers as well as the standard types, for he will at this time appreciate the former and thus interest will be developed. (b) Engineering schools should maintain live student engineers' clubs in which are reviewed current engineering events. (c) Engineering libraries should be in charge of a person familiar with technical literature. Encourage the use of periodicals as references in design subjects and co-ordinate English courses with engineering literature. (d) During at least one semester in the senior year students should meet with engineering faculty for discussion on assigned subjects of moment. These subjects should be selected in such a way that the students become thoroughly acquainted with current periodicals.

2. After graduation. (a) Join a local engineering society and by all means a national society. The local society should have regular junior meetings with discussion of engineering literature. (b) If reading of the more weighty articles does not attract the young graduate he should confine his attention to less serious ones. In this way his reading is not a burden and gradually he will enjoy more critical papers. (c) Employers should encourage reading for young engineers, pointing out the value of keeping abreast of the profession, and should not knock reading knowledge. (d) Engineering editors will do well to print at the beginning of each important article a short abstract of its contents and state its nature, whether research, descriptive or technical, etc., in order that the busy engineer can better utilize his reading time.

A. F. Barnes,
Dean of Engineering, New Mexico College of A. & M. A.

## ECONOMY OF RAIL HAULAGE AT HETCH HETCHY.

To the Editor: In a recent issue of Engineering & Contracting date of Aug. 9, a criticism is made of the decision of Mr. M. M. O'Shaughnessy, City Engineer of San Francisco, to construct a railway for the purpose of hauling some 225,000 tons of freight 68 miles to the Hetch Hetchy Damsite, instead of handling this freight by automobile trucks. The editorial intimates that the decision was reached without serious thought and consideration and asks why Mr. O'Shaughnessy did not consult manufacturers of motor trucks and men experienced in operating trucks before committing himself to this project.

In the same article it is suggested that a motor road be built with long level stretches connected by comparatively short stretches of steep road, at which steep stretches "Pusher" traction engines could be stationed to aid the trucks with trailers in ascending the steep grade. It is further suggested that it might pay to construct in this road concrete rails 24 inches in width and 8 inches in thickness with turnouts in which the trucks might run.

It does not appear to the writer that the suggestions offered are really to be seriously considered, but it is felt that the criticisms should not pass without notice, for in the case of the casual reader or a person not otherwise informed on the subject discussed, such editorials are apt to create and leave with him as his own, the opinion thus editorially expressed, and the conclusion reached therein, no doubt prematurely, and without a full knowledge of the facts, may cause an erroneous impression to become established in the public mind.

The report of the City Engineer of Feb. 17, 1915, which has called forth the criticism, gives as the estimated cost of transporting materials by rail from the connection with the existing railroad to the Hetch Hetchy dam site as 14.9 cents per ton mile, including the cost of constructing and equipping the railroad and allowing 7 cents per ton mile for operation and maintenance; the critic finds no fault with these figures but proposes to effect a large saving by hauling materials to the dam site by auto trucks, to do which means handling freight by motors at less than 14.9 cents per ton mile, including the cost of new road construction and maintenance.

It is of interest to note that since the report above referred to was written, the City advertised for bids for hauling cement by motor truck from Chinese to the Hetch Hetchy dam site, a distance of 58 miles. The tonnage involved in this particular contract is approximately 800 tons. The lowest bid was $23. per ton, equivalent to almost exactly 40 ct. per ton mile, three times the price which the article referred to intimates that this could be done for. The actual cost to the contractor, based on the favorable conditions of road and weather, is 28 cents per ton mile.

The statement contained in the article, "The assumption of 25 cents per ton mile is almost double the prevailing contract price of motor trucking over dirt roads in California," does not seem to be borne out by the City's experience nor by the experience of others and will not bear analysis. Figures showing the cost of motor trucking at less than 15 cents per ton mile, even on paved highways, may be generally set down as the estimated cost of enthusiastic automobile salesmen employed by the "manufacturers of motor trucks," and not the cold figures taken from operating costs extending over a period of time representing the life of a truck, and of course do not include any part of the cost of orginal road construction, or the overhead expense of the going contractor.

The suggestion that a new road be constructed with long level stretches connected with short, comparatively steep stretches, where the trucks and trailers are to be pushed up the incline by a traction engine, is not new. It has been tried on traction engine hauling, where the application would be far more favorable on account of the load per train being much greater, and under these conditions it has not proved the rosy solution indicated in the article, due to the fact that the capacity of the road is limited by the congestion of freight, such steep places and the schedule of operation is broken thereby.

The use of concrete rails suggested is novel in this part of the country at least, and it appears to the writer that a pair of concrete rails 24 in. wides and 8 in. thick, constructed on a mountain road with no adjoining paving, leaving the remainder of the roadway free to wash, would not last through more than a small part of one season and it would be, at the best, a poor substitute for an adequately paved roadway.

The effect on the truck driver following these rails continuously throughout the day or the night would be an element to be reckoned with, to say nothing of the damage to tires due to climbing back onto these rails every time that the truck should skid off of them, particularly after the road surface adjacent to the concrete rails had washed down below the rail surface.

One feature not mentioned in the City Engineer's report and so ignored in the article is the great superiority of the railroad in its ability to readily handle large variations in the volume of freight delivered to the existing railroad connection at different times. By virtue of this, large storage facilities are not required at the present railroad depot and the rehandling of the freight at this point is entirely eliminated, with the result of expediting the entire freight movement. Furthermore, it is possible to handle freight at all seasons of the year at approximately the same operating cost and with a minimum liability of damage in handling. With regard to this item of damage in transit, in connection with the particular contract for handling cement, above referred to, the hauling contractor was required to replace 962 sacks of cement, due to sacks of cement damaged either at the storage point or on the road, and to reduce loss in transit the contractor found it necessary to have all cement double sacked at a cost of 5 cents per barrel for the packing plus the usual charge of 10 cents for the sacks. While it may be claimed that this loss was unusual and avoidable by proper care, nevertheless money must be expended to insure proper care and there will always be a certain amount of loss due to damage in transit, which will be a minimum with railroad operation compared with motor truck haulage, with the rehandling feature which must exist.

Altogether, it does not seem as if the points for criticism are well taken.

Yours truly,
N. A. Eckart, Mem. A. S. C. E.

San Francisco, Cal., Aug. 31, 1916.

[We are glad to publish Mr. Eckart's additional facts supporting the conclusions reached by the city engineer of San Francisco as to the economy of rail haulage to Hetch Hetchy. It was not our intention to imply lack of serious study of the problem, but it still seems to us that the data were insufficient and the results inconclusive. Mr. Eckart cites, in support of the conclusion that motor trucking would have been uneconomic, the fact that a recent bid for hauling 800 tons 58 miles was 40 ct. a ton-mile. But he can scarcely have meant that such a bid is any real criterion by which to estimate the cost of hauling 225,000 tons, for in the case of 800 tons no adequate reconstruction of roads could have been undertaken, whereas in the case of 225,000 tons a very elaborate road building program would certainly be justified.

In an editorial paragraph in our issue of Sept. 6 we cited the experience of the Great Northern Paper Co. which, under the direction of Mr. H. S. Ferguson, consulting engineer, built a 30-mile gravel road over which to haul 20,000 tons of cement for a dam in Maine. Using motor trucks the cost has been half the cost of team haulage. This was not an estimate but an experience.

We entirely disagree with Mr. Eckart's statement that:

"Figures showing the cost of motor trucking at less than 15 cts. per ton mile, even on paved highway, may be generally set down as the estimated cost of enthusiastic automobile salesmen employed by the 'manufacturers of motor trucks,' and not the cold figures taken from operating costs extending over a period of time representing the life of a truck, and of course do not include any part of the cost of original road construction, or the overhead expense of the going contractor."

Many reliable records of actual costs of motor truck haulage are available, and the enthusiastic salesman" is not the sole source of information.

The editor has himself contracted with experienced motor truck owners for haulage at 15 ct. a ton-mile, over roads that were by no means ideal, and through long enough periods of time to justify his belief that such a price was profitable to the truck owners.

Finally, we of course, are not certain by any means that a railway was not justified by the economic conditions at Hetch Hetchy. Mr. Eckart's contention that is justified may be entirely correct. We repeat, however, that the data upon which motor trucking was excluded as being within the realm of economic possibility seem to us to be far from convincing.—Editor.]

During the fiscal year ending June 30, 1916, the U. S. Reclamation Service has increased the area which it is proposed to supply with water for irrigation by about a quarter of a million acres of land and the area under rental contract by over 200,000 acres. The capacity of the reservoirs has been increased 2,500,000 acre-feet. Nearly 1,000 miles of canals, ditches, and drains were constructed during the year, bringing the total up to nearly 11,000 miles. About 8,000 canal structures were built during the year, about 300,000 ft. of pipe laid, and 100 miles of canal lined. The total excavation to date amounts to over 140,000,000 cu. yd., about 10,000,000 cu. yd. of which were excavated during the past year.

The average unit cost of grading for the Bureau of Streets of Philadelphia, Pa., in 1915 was 27 ct. per cubic yard. This figure is based on 116 contracts aggregating 799,488 cu. yd. of excavation.

The Council of Ministers of Russia has approved the insertion in the 1917 budget of an appropriation of $1,500,000 to be expended during the next 5 years for railroad construction.

## PLANT AND METHOD OF DRY EXCAVATION, LIVINGSTONE CHANNEL, DETROIT RIVER.

The use of the dry method of excavation on a portion of the Livingstone Channel improvement of the Detroit River for the U. S. Government made the cost of this undertaking about $600,000 less than it would have been by the usual subaqueous method, as indicated by the prices named in the proposals for the work. The improvement of the channel throughout the greater portion of its length was made by the usual subaqueous method of earth and rock excavation, the equipment consisting of dredges, drill boats and other floating plant. However, for a length of about 1 mile abreast of Stony Island near the north end, the channel way was surrounded by earth dams, the inclosed area unwatered and the excavation made by the dry method. This work was carried out by the contractors, Grant Smith & Co. and Locher, in an unusually expeditious manner. In the November-December Professional Memoirs, Mr. C. Y. Dixon, assistant engineer, describes the equipment and method employed. The matter that follows has been taken from Mr. Dixon's article.

Within the area inclosed by dams, there was very little earth covering to the rock and the depth of rock cutting varied from 12 to 18 ft. The rock was a Dolomitic limestone of Silurian formation, lying in strata of from 1 to 4 ft. thick. Prior to the completion of this improvement Congress, by act of June 25, 1910, authorized the widening to 450 ft. of that portion of Livingstone Channel inclosed by dams.

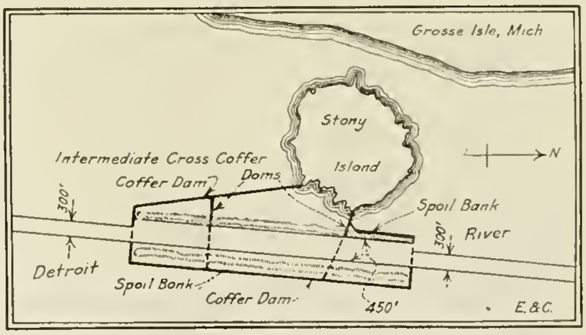
The contractors leased Stony Island,. which was privately owned, for the period of their contract and used it as a base of operations. On the east shore of Stony Island there was installed an air-compressor plant which was substantially housed; also, there were erected on that island about 40 buildings, including repair shops, warehouse, store, rooming house, mess hall, school house, and a number of dwellings for employes. Work on this improvement was in progress during about 40 months, from April, 1908, to December, 1911.

The plant and equipment used on this work was as follows: One air-compressor plant; one small locomotive with eight flat cars for handling supplies operated on about 1½ miles of track; 17 pumps of various sizes, from 4-in. to 18-in.; 14 portable tripod drills; five traction drills; three channelers; three steam shovels, and three cableway conveyors of excavated material. Also, there were used for building dams two derrick boats, five flat scows and three launches. The number of employes varied from 142 to 312, the average being about 250.

The total length of channel surrounded by dams was about 5,800 ft., and the inclosed area had an average width of about 1,200 ft., being about 160 acres. This area was divided into three parts, each surrounded by dams and unwatered separately. The work of building the dams was begun April 14, 1908. The dams around the central portion of 2,800 ft. channel length were completed Oct. 5, 1908; those around a channel length of 1,200 ft. at the south end were completed Sept. 4, 1909, and those around a channel length of 1,800 ft. at the north end were completed Aug. 10, 1909. Each area was unwatered as soon as the inclosing dams were completed, and after the unwatering of the end areas the intermediate dams crossing the channel were removed. The length of dams surrounding the central area was about 8,700 ft. The additional length of dams around the south area was about 3,600 ft., and that around the north area was about 4,800 ft. The locations of dams and of the improved channel are shown in accompanying sketch.

**Dam Building.**—The dams were built of earth, except at the upstream end where broken rock was first placed as a backing to prevent the earth from being washed away by the strong current. All material entering into the construction of dams was excavated from other portions of this improvement, loaded on flat scows by the dredges, the loaded scows towed to the site of the dams by tugs and launches and there unloaded. The unloading was done by a derrick boat with engine equipped for dragging a scraper across the deck of the loaded scow. The loaded scraper was dumped on the site of the dam, although much of the material fell into the water at the side of the scow. This material was later cast over by a dredge, to form the top of the dam. The dams were built up to about 5 ft. above the normal stage of water; their width at top was about 5 ft. and their sides assumed a slope of about 2½ to 1 in water varying in depth from 8 to 12 ft. The amount of material used in the construction of dams was about 433,000 cu. yd.

**Pumping.**—The work of unwatering the central area of 2,800 ft. length was begun Oct. 5, 1908, by the use of two 12-in. centrifugal pumps and an air lift consisting of 48 8-in. pipes. These pipes were suspended at an inclination of about 30 degrees from the vertical and extended from about 1 ft. above the water surface nearly to the bottom of the river. Compressed air admitted at the lower end of the pipes caused the water to be discharged from the pipes into a sluice-way, through which it flowed into the river. This air lift was very efficient until the water had been lowered from 12 ft. depth to about 7 ft. depth, when the air was forced through the water without raising it. The use of the air lift was then discontinued. The work of unwatering this area was so far completed that the operation of channelers and rock drills was begun Oct. 19, 1908. Further pumping was done as required by the progress of the work of excavation. The leakage through the dams was small, and after the initial unwatering the amount of pumping was mainly that due to rains and melting snow. The number of pumps in use varied from time to time. There were in use for a part of each day two stationary pumps of 12 and 18 in. in size, one at each end of the inclosure, discharging directly into the river; also, there were a number of smaller pumps placed where needed for various short periods of time, discharging into sluice-ways or ditches through which the water flowed to either end of the inclosure, where it was discharged into the river by the stationary pumps. The total time during which pumping was done while this work was in progress was from Oct. 5, 1908, to Nov. 2, 1910, and from March 4 to Dec. 23, 1911, being a total of 1,054 days. The number and size of pumps used, the total number of hours worked by pumps and the average number of days of 24 hours worked by each pump were as follows:



Sketch Showing Location of Dams and Channel.

| Number and size of pumps. | Total number of hours worked. | Av. number of days of 24 hrs. each worked by each pump. | Total number of days during which pumping was done. |
|---|---|---|---|
| 1 18-in. pump......... | 17,905 | 746.0 | 1,054 |
| 3 12-in. pumps........ | 24,873 | 345.5 | |
| 9 8-in. pumps........ | 82,145 | 380.3 | |
| 3 6-in. pumps........ | 16,505 | 229.2 | |
| 1 4-in. pump......... | 1,779 | 74.1 | |

All operations in connection with this work were suspended from Nov. 3, 1910, to March 3, 1911, through no fault of the contractors, and the necessary pumping during that interval is not included in this statement.

**Channeling.**—Prior to blasting the rock to be excavated, that along the side lines was cut to the required depth by channelers, which were air driven and three in number. Each channeler was operated by three men working in eight-hour shifts, usually for 16 hours per day. The record of work done by channelers was as follows:

| No. of machine. | Months employed. | Hours worked. | Hours delayed | Square feet channeled. | Rate of channeling per hour. |
|---|---|---|---|---|---|
| 229 | 31 | 7,018 | 1,832 | 90,452 | 12.9 |
| 318 | 32 | 7,032 | 1,998 | 99,474 | 14.1 |
| 460 | 21 23/30 | 5,308 | 2,308 | 60,234 | 11.3 |
| Totals | | 19,358 | 6,138 | 250,160 | 12.9 |

**Drilling and Blasting.**—The work to be excavated between the channeled side lines was broken by drilling and blasting. The number of small portable tripod drills used varied from five to fourteen. Also, there were used at different times five traction drills mounted on trucks. These traction drills were equipped for "pinning up," so as to be rigid when in operation and with a special device for washing out the sludge, making them much more efficient than the small portable tripod drills. All drills were air-driven, and each was operated by two men working in 8-hour shifts, usually for 16 hours per day. The holes were usually drilled at the corners of 6-ft. squares. In blasting the rock two grades of dynamite were used, 60 per cent and 40 per cent, the latter near the side lines to lessen the danger of shattering the channeled face of wall. The record of work done by the portable and traction drills, and of the amount of dynamite used, was as follows:

| | Drill-hours. | | | | Dynamite used | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Worked. | Delayed. | Holes drilled. | Linear feet drilled. | 60 per cent pounds. | 40 per cent pounds. | Total pounds. | Rate of drilling per hour. | Dynamite per linear foot. |
| Portable drills | 125,614 | 10,579 | 116,970 | 649,870 | 552,378 | 498,737 | 1,051,115 | 5.2 | 1.6 |
| Traction drills | 7,774 | 3,068 | 8,747 | 101,973 | 86,210 | 77,838 | 164,048 | 11.8 | 1.6 |
| Totals | 133,388 | 13,647 | 125,717 | 751,743 | 638,588 | 576,575 | 1,215,163 | 5.6 | 1.6 |

**Excavation.**—The material was excavated by steam shovels and deposited in skips or iron baskets of about 5 cu. yd. capacity, which were carried by cableway conveyors about 400 ft. to points back of either side of the channel and there dumped. There were used three shovels and three cableway conveyors. The conveyors were operated by compressed air, and they were suspended from two towers about 100 ft. high, one on each side of the channel. As the work advanced the cableway towers were moved forward on tracks in order to keep abreast of the steam shovels. Following the steam shovels, a gang of laborers cleared the bottom of all loose rock, which was placed in the skips by hand. Then the elevations of the highest points of the bottom were obtained by the use of a surveyor's level to insure the required grade being made, and where necessary high points of rock were removed by further drilling and blasting, and by hand labor. Thus, as the work advanced it was left completed. The steam shovels and cableway conveyors were operated in 8-hour shifts, usually for 24 hours per day. The number of men in each shift with steam shovel and cableway conveyor was 3 on steam shovel, 2 on cableway conveyor, 1 bell-boy to give signals for operating cableway, 1 man to hook skips to cableway, and 1 foreman and 6 laborers excavating by hand labor, being a total of 14 men. The record of work done by steam shovels and by hand labor was as follows:

| Steam shovel. | Months employed. | Hours worked. | Hours delayed. | Material removed Earth. cu. yd. | Rock, cu. yd. | Total, cu. yd. | Av'ge rate per hour, cu. yd. |
|---|---|---|---|---|---|---|---|
| 1181 | 26 6/30 | 9,585 | 3,359 | 13,004 | 460,266 | 473,270 | 49.4 |
| 1187 | 30 5/30 | 10,002 | 2,618 | ....... | 571,172 | 571,172 | 57.0 |
| 1463 | 29 21/30 | 9,851 | 2,280 | 208,608 | 364,491 | 573,099 | 58.2 |
| Hand labor | ........ | *51,800 | ..... | 2,027 | 19,461 | 21,488 | .... |
| Totals | | | | 223,639 | 1,415,390 | 1,639,029 | .... |

*Man-hours.

**Use of Compressed Air.**—Compressed air was the principal motive power for pumps, channelers, drills, cableway conveyors and shops. The compressor plant consisted of two units, one of about 700 H.P. and one of about 300 H.P. Usually, during working hours, the compressor plant was operated to full capacity; but at night when only a portion of other plant was at work, and on Sundays when only the pumps were in use, one compressor working at low speed furnished ample power for all purposes. There was therefore frequent opportunity for repairs to compressors and they were kept in excellent condition throughout the entire period of the work. This plant was operated by men working in three 8-hour shifts per day. The force of each shift consisted of 1 engineman, 2 oilers, 1 fireman and 2 laborers. The air was delivered to the main line pipe under a pressure of 90 lb. per square inch, at a temperature of 230° F. The main line pipe was 8 in. in diameter and about 7,500 ft. long and it was placed on top of the dam surrounding the inclosure. At frequent intervals along the main line pipe, distributing pipes from 1 to 6 in. in diameter conveyed the compressed air to points on the work where needed. The pipe lines required the constant attention of about four men in laying and shifting distributing lines, in stopping air leakage and in drawing off condensed moisture. During cold weather fires were necessary at frequent intervals under the pipes to prevent moisture from freezing and stopping flow of air. Also, for greater efficiency the compressed air passed through reheaters before use in the operation of channelers and cableway conveyors.

The relative cost of each item of work incident to the excavation and disposal of rock was approximately as follows:

| Items of work. | Percentage of total cost. |
|---|---|
| Cofferdam construction and removal | 8.7 |
| Pumping | 10.0 |
| Channeling | 3.0 |
| Drilling | 15.2 |
| Blasting | 17.5 |
| Excavating | 22.6 |
| Conveying and disposal of material | 16.5 |
| General expenses | 6.5 |
| Total | 100.0 |

The amounts of earth and rock excavated within the cofferdam inclosure; the amounts paid the contractors for excavation, including cofferdam construction and later removal of dams crossing the channel, and the approximate average cost to the United States per cubic yard, was as follows:

| Material. | Cubic yards. | Amounts paid to contractors. | Approximate average rate per cubic yard. |
|---|---|---|---|
| Earth | 223,639 | $ 129,746.05 | $0.58 |
| Rock | 1,415,390 | 1,786,929.88 | 1.26¼ |
| Total | 1,639,029 | $1,916,675.93 | $1.17 |

The cost of this improvement was about $600,000 less than it would have been by the usual subaqueous method, as indicated by prices named in proposals for the work. In addition to this saving, the work was done in about 75 per cent of the time that would otherwise have been required and vessels using this channel are much less liable to injury, because of the smooth vertical sides and nearly even bottom. Livingstone Channel was formally opened to navigation on Oct. 19, 1912.

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The citizens of St. Augustine, Fla., have voted to retain the commission-manager plan of city government. At the election Nov. 8 the candidates for the city charter board pledged to commission-manager government—in other words, the present charter, with possibly slight modifications—were elected over the candidates who proposed to upset commission-manager government, by a vote of more than two to one. The commission-manager charter of St. Augustine was adopted in June, 1915, by a bare majority of 18 votes. The average majority on the recent election was 329 votes. The three present commissioners as candidates for the charter board, led the ticket.

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The city of Baltimore, Md., on Nov. 8 voted a $3,000,000 loan for further street improvements. Of the amount $2,000,000 is for pavements in the annex and $1,000,000 for work in the old city limits.

## DRAG LINE OUTFIT SAVES 2-MILE HAUL.

The drag line outfit shown in the accompanying illustration saves a 2-mile haul for gravel. The installation is located about 1½ miles west of the town of Casper, Wyo.

The material on both sides of the river is gravel, but that on the near side contains too much loam and silt, while the material on the opposite side of the river is in proper proportion for use in making concrete. This plant was installed both to load and to haul the gravel from the opposite side of the river. As the nearest crossing is a mile up stream away from the town of Casper, the equipment saves this 2-mile haul. There is also some excellent gravel in the bottom of the stream and it is the intention to excavate this as soon as the supply is pretty well exhausted on the opposite side.

The bucket is the back dump Pioneer excavating bucket of 1-yd. capacity. The pole is 12x12 Douglas fir, spliced in the middle at the spider. The spider is 7 ft. across between tension rods. The tension rods are 1⅛ in. diameter and are provided with turn buckles to take up the stretch in the rods. Shoes are provided at both ends of the rod and fastened rigidly to the pole so that the slip is reduced to a minimum. All blocks at the top of the pole are hitched with three loops of ⅞-in. steel cable and have never given any trouble since installation. The bucket operates on a 1¼-in. Hercules wire rope about 600 ft. long, and the drag cable is ⅝ in. in diameter, the same make of rope. The blocks are of large diameter and self-lubricating. Five guy wires, 1-in. diameter, are provided to resist the pull on a track cable which is quite large, as the bucket and load weighs about 5,500 lb. A boiler burning fuel oil and a 40 H.P. double drum hoisting engine are used to operate tension and drag cables. With this equipment two men only are needed—a hoisting enginer and a fireman. A round trip is made in about 2½ minutes on an average.

Drag Line Gravel Excavating Outfit Operating Across River.

Unloading End of Cableway.

The bin was built low for the reason that later on it is expected that a screening equipment will be added. Gravel from the bin is dumped by gravity directly into the wagons by a chute, as shown in one of the illustrations.

The equipment was furnished and installed by H. W. Moore & Company, Denver, Colo., for Mills & Baker, contractors of Casper, Wyo.

## A $1,000,000 RAILROAD IMPROVEMENT AT BOSTON, MASS.

The New York, New Haven & Hartford R. R. will expend about $1,000,000 for improvements at the South Boston cut, Boston, Mass. Nearly all the freight which the New Haven road carries into or out of Boston has to pass through this cut. This is a narrow walled cut, with barely room enough for two tracks passing under eleven low highway bridges which give very little clearance above the tops of the present locomotives and cars.

It is expected to obtain the increased capacity, first, by increasing the space available for the larger equipment on the present two tracks, and second, by providing room for two additional tracks capable of using this larger equipment.

To obtain greater overhead clearance, it is proposed to lower the tracks as much as possible without getting too far below tide water, the maximum lowering being about 4 ft. The lowering of the tracks does not give quite sufficient overhead clearance and some of the 11 overhead bridges are to be raised slightly, this raising being kept at a minimum so as to injure as little as possible private property fronting on the streets affected.

To get room for the two additional tracks land has been purchased on the southeasterly side of the present tracks, so that four tracks with ample space between them will be made available.

The bridges now crossing over the cut will be entirely rebuilt of steel, with solid floors and will span the four tracks. The four narrow bridges at Bolton street, Athens street, Silver street and Gold street will have wood block paving and the bridges at West Second street, West Third street, Broadway, West Sixth street and Dorchester avenue will have granite block paving. All of the streets wherever changed in grade will be resurfaced and left in as good condition as at present.

## LEASING CONTRACTOR'S TRUCKS AT END OF CONSTRUCTION SEASON.

As the motorizing of the coal handling business is scarcely begun, one of the most inviting fields for the contractor is the hiring of his trucks to coal merchants whose busy season begins to advance as the contractors' recedes. The picture of the 7-ton Sterling truck owned by Anderson Brothers, haulage contractors of Cincinnati, O., is an excellent illustration of a dual-purpose motor truck. During the spring and summer, Anderson Brothers haul sand and gravel, brick and stone for the materials dealers of their city. Instead of letting their relatively expensive piece of efficiency equipment lie idle during the winter season, they lease it to the coal merchants and keep it going all the year round.

Dual Purpose Truck of Anderson Bros., Cincinnati, O.

Anderson Brothers' equipment is a combination of double deck or convertible automatic dumping truck. The body is constructed in two sections longitudinally, the capacity of the lower section being proportioned so as to handle a full load of sand and crushed stone or builders' materials. The flanges of the body are drilled to receive the upper section and by bolting the two decks together, the capacity is sufficient to handle 7 tons of soft coal with a reasonable margin for overloading by crowning. The demounting of the upper deck can be accomplished with no more tools than a stout wrench and an overhead crane in less than 15 minutes' time.

The upper section contains hinged steel dividing plates so that when used for coal handling, the truck becomes a compartment body machine so that if the coal dealer renter sells mainly to retailers, tonnages of 3½ or fractional amounts can be delivered independently.

It is of course readily practicable to design the upper deck of such dimensions as will enable the combination of the two decks to handle anthracite coal and a variety of other bulky materials which the haulage contractor may lease his trucks to transport, such as shavings, sawdust, etc.

While the possibilities of mounting the dumping body on a platform bed with stake holders for converting it into a mercantile truck at the end of the contracting season are large, very few have adopted it.

An excellent example of the elimination of non-productive time in motor truck operation in the coal handling business is given below:

The Callaway Fuel Co. of Milwaukee uses a Sterling 3½-ton truck in retail coal business in the following manner:

The truck after being loaded from overhead hoppers proceeds with its load of helpers to the consumer's premises. It may happen that the consumer may be a private residence having need for only 500 to 1,000 lb. of fuel. In this case, the heavy canvas bags of 100-lb. capacity are loaded with the required amount and delivered through the flour bin type of chute at the rear end of the body, the hydraulic hoist tilting the dumping body sufficiently for the fuel to flow gently. In the event that a bulk load is to be delivered, the large canvas is spread upon the pavement in front of the residence or business premises, the entire load dumping in a heap and the truck immediately proceeds to return to the loading point, the helpers being left behind to put the coal in the premises. In case of a concentrated business district where there is a side or rear alley or even a street not congested by traffic and a number of deliveries are made in the same neighborhood, the helpers may, after putting in the coal, walk to the next place of delivery, the address of which has been given them by the driver with the routing card

It is not always practical to so route the loads as not to detour considerable mileage each day to pick up the helpers. This especially true of deliveries in residential districts since one customer may be delivered a load two or three miles distant from the next, necessitating either the helpers proceeding by street car to the next home or the truck detouring to pick them up.

The non-productive time in the operation of picking up the helpers is less than under the horse wagon system. Under the crude system of some motor coal truck users, who keep the truck standing while the helpers are taking off the load, hardly 50 per cent of the operating day is productive.

## REVOLVING PILE DRIVER.

In the construction of the jetty works at the mouth of the Columbia River for the U. S. Government the revolving pile driver shown in the accompanying illustration was used. This driver is of original design and was adopted on several of the works on the Pacific coast on account of its economical and efficient work. The following description of the driver is taken from the November-Decembe Professional Memoirs of the U. S. Corps of Engineers:

The pile driver is of the revolving platform combined hammer and jet type. It is mounted on four double trucks of 8 wheels each, making 32 wheels in all, traveling or double tracks, 13-ft. centers, making a wheel base 16 ft across the tracks and having an extreme longitudinal bas of 22½ ft.

The car which supports the base for the revolving plat

Truck Delivering Small Loads of Coal.

Truck Delivering Bulk Loads of Coal.

form to rest on is built up of trussed wooden beams, forming a strong rectangular framework which extends over, and runs on, both tracks, each of the four corners of the car being supported by a double truck in such a way that each track takes its share of the load. On this base a revolving track 16 ft. in diameter is built of 30-lb. rails. On the under side of the platform is a track, also of 30-lb. rail, which coincides with the track on the base, and the platform revolves on steel rollers placed between these tracks. The rollers are caged, so as to maintain spacing.

Inside the roller path is a large gear wheel into which meshes a pinion from the engine on the revolving platform; thus the entire working part of the driver is revolved at will by the engine.

Aside from the jet pump, the entire working parts of the driver are mounted on the revolving platform. The jet pump is mounted on a platform attached by hoisting lines to the main car platform, as owing to the height of the driver above low water it is necessary to lower the pump below the track level. The stream is led to the pump through a flexible suction hose and the discharge water is carried through the center pivot casting of the revolving platform.

Revolving Pile Driver.

The revolving portion consists of a braced platform constructed on the cantilever principle. It is 66 ft. long and has a clear overhang beyond the trucks of 22 ft. The compression members are of timber and the tension members of round steel. On one end gins 72 ft. high are erected, and on the other is placed a locomotive type boiler, fuel and water. In the center is an 8¼ by 10 in. double cylinder, double drum, link reversing, hoisting engine, which besides the work of pile-driving also revolves the driver by means of gearing through a friction clutch. A shelter of wood is built over the boiler and engine. The jet water comes through the center pivot and divides into two 2½-in. branches; each branch is carried through a hose over a 5-ft. sheave, which is counterbalanced, thus keeping the slack out of the hose.

This pile driver has worked so satisfactorily that it has not been necessary to make any modifications in the recent ones built for similar work on the Pacific coast. The cost of a complete driver is approximately $11,000, when built in the government shops.

## METHOD AND GENERAL COST OF ROCK EXCAVATION FOR THE INLET SWAMP DRAINAGE DISTRICT, ILLINOIS.

The Inlet Swamp Drainage District comprises 32,000 acres of rich muck land in Lee County, Illinois. It lies between the Chicago & Northwestern Ry., the Illinois Central Ry. and the Chicago, Milwaukee & St. Paul Ry. The district is 15 miles long and from 1 to 5 miles wide. The point where Inlet Swamp ends and Green River begins is known as the Inlet. This is a limestone ledge 4 miles wide and of unknown depth which acts as a dam at the lower end of the swamp. The river, in years past, had cut a narrow channel through this ledge but its capacity was small. Under two early contracts the Inlet was dredged to a bottom width of 30 ft. and a depth of 6 ft. In 1912 the Commissioners of the District awarded a contract to the Northern Construction Co. of Elkhart, Ind., for the enlargement of existing open ditches, the construction of new ditches and the cleaning out of existing ditches. The work included 172,000 cu. yd. of rock excavation and over 1,000,000 cu. yd. of earth excavation, the total contract price being approximately $272,500.

The rock excavation was about 85 per cent bottom work and 15 per cent side work. The base width was 40 ft., and the side slopes ¼ to 1. The contract price was 98.84 ct. per cubic yard. The methods employed in handling this portion of the work were described by Mr. A. W. Naylor in a thesis prepared for the Missouri School of Mines and Metallurgy, and the matter that follows has been taken from that paper.

The equipment used on the work was as follows: A 2-cu. yd. capacity dipper dredge, with 70-ft. boom, telescopic bank spuds and double hitch type swinging engines, made by the Marion Steam Shovel Co. The wood hull was 90 ft. x 34 ft. x 7 ft. and cost complete $8,000. The machinery cost $11,150. The drills were the E-44 steam type fitted 44 head, 44 shell and 42 chuck and were purchased from the Ingersoll-Rand Co. They cost $208 each. The E-27 tripods complete cost $45 each. The cross bits used had a 1⅛-in. shank.

In order to avoid drilling the rock, which was under water from 1 to 5 ft. in depth, from barges, two crib dams were built, one at the upper end of the Inlet, and one two miles from the lower end. The water was held by these dams during the day and allowed to flow through the gates, with which the dams were equipped, during the night. This made it possible to drill the rock dry, and to carry on the work into the winter months. This also necessitated the work being started at the lower end of the ditch.

The holes were drilled approximately 5 ft. apart. The outside holes were 1½ ft. to 2 ft. outside of the slope line. The holes were all drilled approximately 3 ft. below grade, after experimenting on the first 300 ft. This broke the rock a little below grade and with the exception of the first few hundred feet, it was never found necessary to drill and blast the second time.

The rock varied in depth from 1 ft to 8 ft. and, in places, was covered with loose rock and sand from 1 ft. to 3 ft. in depth.

Forty and 60 per cent dynamite was used and the charges were fired by a battery, 40 to 60 holes at one time, usually at noon and at night when all of the men were out of the ditch.

The dredge was built in Green River below the rock, and began excavating as soon as the first rock was blasted. The excavation was kept as close as possible to the drillers at all times.

A brush dam was built in the river below the dredge to control water for same, and to allow it to work under the most favorable conditions. It was only found necessary to build two dams for this purpose. The second one was located about two miles from the lower end of the ditch, after the dredge had passed this point.

The dredge was only operated during the day. The 10-hour shift was sufficient to take care of the rock as rapidly as it was blasted.

This rock was wasted along the banks, leaving a berm of 5 ft.

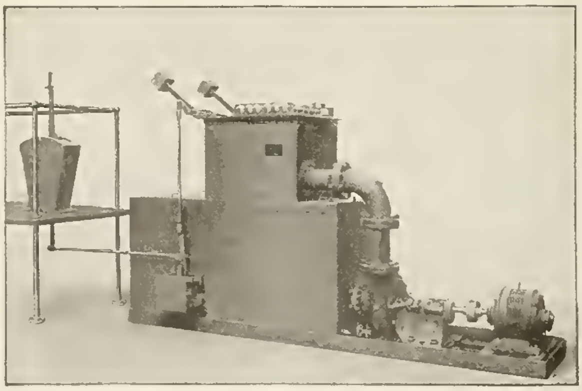
Steam for the drills was furnished by a traction engine and a boiler mounted on a truck.

The actual construction work was started May 3rd, 1913, and completed Dec. 15th, 1915. The work covered a distance of 21,350 ft. The average cut was 7 ft. The following table shows the cost record for excavating the rock:

| | Stripping. | Drilling. | Blasting. | Dredging. | Totals. |
|---|---|---|---|---|---|
| Supt. office and overhead... | $ 765 | $ 6,369 | $ 2,425 | $ 3,190 | $ 12,751 |
| Labor | 2,610 | 24,736 | 2,844 | 7,972 | 38,163 |
| Board | 915 | 9,637 | 507 | 2,536 | 13,596 |
| Team work | 134 | 1,510 | 357 | 550 | 2,552 |
| Coal, including freight | 1,382 | 5,243 | ..... | 5,003 | 11,629 |
| Lubricating oils | 65 | 326 | ..... | 272 | 664 |
| Cables | 302 | ..... | ..... | 969 | 1,271 |
| Dredge repairs | 527 | ..... | ..... | 3,302 | 3,829 |
| Drills and repairs | ..... | 4,089 | ..... | ..... | 4,089 |
| Boiler repairs | ..... | 1,713 | ..... | ..... | 1,713 |
| Drill sharpener repairs | ..... | 402 | ..... | ..... | 402 |
| Drill bits | ..... | 460 | ..... | ..... | 460 |
| Boiler chemicals | ..... | 72 | ..... | 46 | 119 |
| Traction engine repairs | ..... | 405 | ..... | ..... | 405 |
| Blasting repairs | ..... | ..... | 120 | ..... | 120 |
| 60% dynamite | ..... | ..... | 16,992 | ..... | 16,992 |
| 40% dynamite | ..... | ..... | 11,214 | ..... | 11,214 |
| Fuses | ..... | ..... | 2,317 | ..... | 2,317 |
| Rubber boots, clothing, etc. | ..... | 1,504 | 133 | 28 | 1,666 |
| Dams and maintenance | 565 | 967 | 393 | 1,629 | 3,555 |
| Sundries exp. | 62 | 1,982 | 589 | 500 | 3,135 |
| Removing bridges | 150 | 22 | ..... | ..... | 173 |
| Rental, depreciation, etc. | 843 | 4,350 | 182 | 3,553 | 8,929 |
| Premium on bonds | 53 | 260 | 150 | 121 | 584 |
| Liability insurance | 62 | 348 | 496 | 153 | 1,060 |
| Total | $8,441 | $64,405 | $38,724 | $29,330 | $141,402 |
| Extra work, dismantling dredge, etc. | | | | | 5,298 |
| | | | | | $146,700 |

## LIQUID RHEOSTATIC CONTROL FOR LARGE ALTERNATING CURRENT WOUND-ROTOR MOTORS.

The extensive use of electric motor drive for mine haulages, hoists, dredges, and similar applications brought to the fore the necessity for a controller for large wound-rotor induction motors which would give wide and accurate speed variation, positive time limit acceleration, and allow the motor to run at reduced speeds for long periods. To meet these conditions the Westinghouse Electric & Mfg. Co. of East Pittsburgh, Pa., designed the liquid type of control which is shown in the accompanying illustration. These controllers have been in successful operation in various applications for the last four years and have proven equal to the most severe requirements.

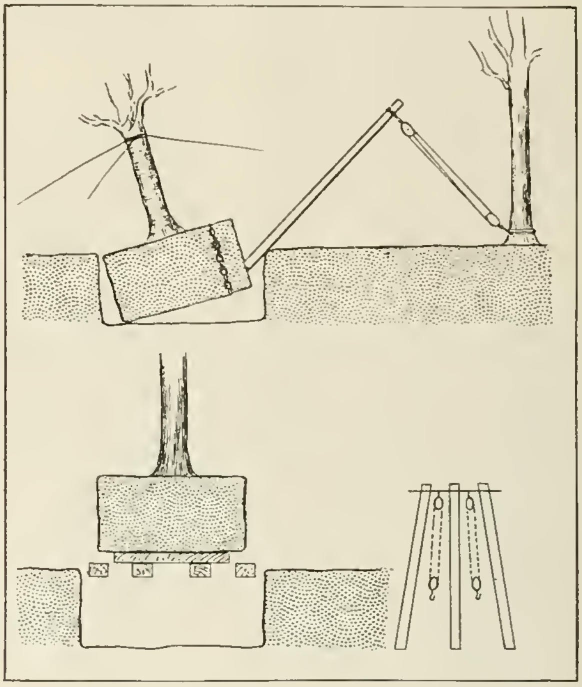

View of Liquid Rheostatic Control Outfit.

In the type of control shown the depth of the liquid, in which the electrodes are immersed is varied. This principle insures smooth acceleration and close speed regulation of the motor as an infinite number of steps can be obtained by gradually varying the depth of the liquid. It eliminates objectionable jerks and sudden strains in both the cable and equipment when starting loads of large inertia. The construction and operation of the control is so simple that even an inexperienced operator can obtain good results, and maintenance costs are low, since the electrodes are practically the only parts requiring renewal and these very infrequently. It is of especial value for heavy duty reversing service when starting is frequent and the motor is run at reduced speeds. It is furnished for any primary voltage and frequency and for either two or three phase.

## METHOD OF TRANSPLANTING HALF GROWN TREES.

In Vertical Farming Magazine for November, Mr. N. D. Rand gives the following description of the methods employed in transplanting half-grown maple trees.

In August 53 trees were selected for transplanting. These ranged from 25 to 30 ft. in height, with a spread of 10 to 12 ft. The best specimens were selected and a strip of white cloth tied around the tree for identification. In September a trench was dug around each tree. This trench was about 18 in. wide and 3½ ft. deep, and from 2½ ft. to 3 ft. from the tree, leaving a ball of earth 5 or 6 ft. in diameter. As soon as the trench around each tree was completed it was packed tightly with straw and a couple of inches of earth thrown over the straw to hold it down. Care was exercised in cutting the roots to leave a clean, smooth wound to aid in callousing.


Method of Removing and Resetting Tree.

The holes for the trees were then dug on each side of the avenue. These holes were made about 8 ft. in diameter and 4 ft. deep and gave ample space to work around the ball of earth, and to fill in with rich mellow soil for the development of root fibres. The center of each hole was drilled to a depth of 5 ft. and fired with a charge of one stick of 20 per cent Red Cross Extra. Twenty-six and a half pounds of dynamite were used with 53 No. 6 caps and 265 ft. of fuse. The subsoil layer of hardpan averaged from 5 to 6 ft. deep, and it was thought best to place the charge at the bottom of this and sufficiently heavy to break up the entire layer.

In January after the ground had frozen to a depth of 3 ft. the straw was removed from the trenches. A gin was constructed of three stout poles with a steel bar through the top. From this bar hung two 1½-ton chain hoists, as shown in sketch. By means of stout poles, one end prying against one side of the ball of earth and the other fastened to tackle blocks, the ball was raised sufficiently to pass a chain under. This operation was repeated on the opposite side and the gin was then placed in position and each chain fastened to a chain hoist and three ropes secured about two-thirds up the tree to steady it. The tree was then raised until the bottom of the frozen ball of earth was about a foot above the top of the ground. Three pieces of 4x4 were slipped under the tree and then a large stone boat was pulled under, resting on the 4x4s. The tree was then lowered to the stone boat and hauled to the desired location, being steadied on the way by the three guy ropes.

Unloading was a very simple matter. The heavy 4x4s were placed over the hole and the stone boat drawn on until the tree was in the center. The tree was then pulled over to one side by the guy ropes and the stone boat drawn out, allowing the tree to rest on the heavy timber. The horses were then fastened to the timbers and each one drawn out, which allowed the tree to slip into the hole. Before taking the tree out of the woods, the south side was determined and the tree transplanted in the same relative position.

The cost of moving the trees was approximately $6.50 per tree, which did not include digging the trenches, digging the holes for the trees or blasting. Five men, a foreman and team of horses were employed. For the digging, the same foreman and a crew of six Italians were employed.

## EXPERIMENTS TO DETERMINE FROST ACTION ON SAND.

During the development of the plans for the Yale Bowl—the athletic field for Yale University at New Haven, Conn.—two questions were raised concerning the probable stability of a concrete structure built on an earth slope varying from 1 on 2½ to 1 on 4: First, whether expansion and contraction, due to temperature changes, and the heaving effects of frost in the underlying sand would not gradually move the concrete down the slope and, eventually, pile it in a disordered heap at the bottom; and, second, whether material in the embankment could be compacted so solidly that subsequent settlement would not crack the concrete injuriously.

To answer the first of these questions so far as possible a few simple experiments were made regarding frost action. A description of these experiments is given by Charles A. Ferry, M. Am. Soc. C. E., in the October Proceedings of the American Society of Civil Engineers, Vol. XLII, No. 8, pages 1,320-21, from which the following notes are taken: A sample of the sand was taken from the field within a few hours after a very heavy rain, and it was found that only about 23 per cent of the volume of the voids was filled with water, the total volume of the voids being about 37 per cent of the volume of the sand when compacted. A bottle, about 10 in. in length and 1 in. in diameter, with a sharply contracted neck, was then filled with sand thoroughly compacted, and with sufficient water added to fill 23 per cent of the voids. The mixture was then frozen, but no indication of any expansion of the mass was noticed. A similar experiment with 50 per cent of the voids filled with water produced a like result. The experiment was then repeated with 75 per cent of the voids filled, and the bottom of the bottle was cracked off.

To ascertain the extent to which water would be retained in the sand by capillary action, the bottle was filled with sand saturated with water. A piece of linen was then tied over the mouth of the bottle which was then reversed and the water allowed to drip. In 2 minutes about 16 per cent of the water had run out. The bottle was then set, mouth down, in a bed of sand, the broken off bottom being replaced in order to lessen evaporation from that end. After 24 hours 67 per cent of the water had run out, and 80 per cent at the end of 8 days. It was concluded, therefore, that, as the slope was to be entirely covered with concrete, thereby excluding all water except such as could pass through the expansion joints, the danger of any disintegrating effect resulting from frost in the underlying sand might be neglected.

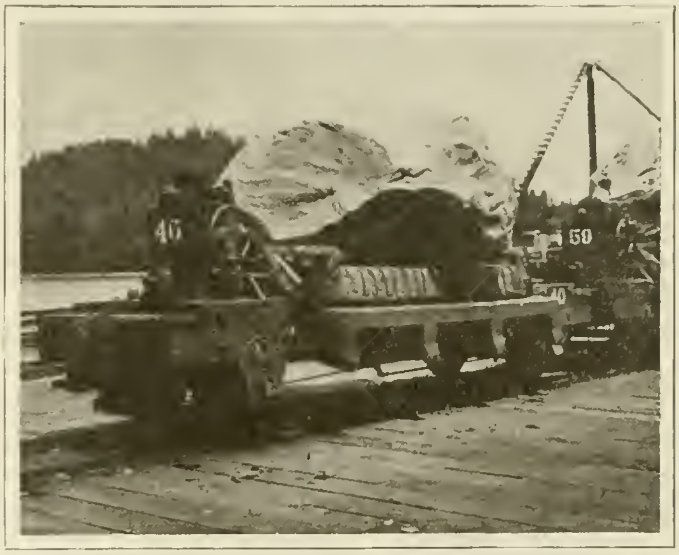
## ROCK DUMP CAR.

Geared dump cars of the design shown in the accompanying illustration have been used on several government works on the Pacific Coast, and have proved economical and efficient. The description that follows is taken from the November-December Professional Memoirs of the U. S. Corps of Engineers.

This car is of the hand-operated geared type and was first built in 1889. It consists of two 2-wheel pony trucks joined together by an 8-in. I-beam extending the full length of the car and having a link and pin coupler on each end. Near each end of this beam is a rectangular framing carrying at one end a cast-iron trunnion bearing for the swinging platform and also the dumping gear for operating the swinging platform.

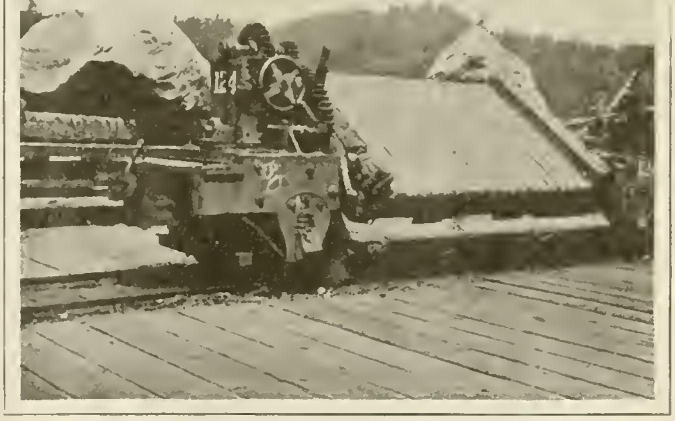
The dumping platform or box is built of heavy timber protected by Norway iron straps to take the wear of the stone. It rests on the swinging platform, being held in place by two guides so that it can be easily removed for loading.

The swinging platform is built of timbers and structural steel. At the operating end a gear segment is securely bolted to it; the center of the segment coincides with the trunnion. The height of the trunnions is such that they are above the center of gravity of the empty platform and below it when the platform is loaded, which is quite important in facilitating dumping the load. It requires approximately about half a minute to dump each car.



Hand Operated Rock Dump Car.

The dumping gear consists of a pinion which gears with the segment attached to the loading platform. This pinion is keyed to a shaft near the other end of which is a worm gear which, in turn, gears with a worm on the hand-wheel shaft. The shaft of the pinion is carried in bearings on top of the pedestal. The shaft of the hand-wheel is contained between vertical guides and is held in position by a horizontal releasing pin under the hand-wheel. When a car is to be dumped, a few turns are given to the hand wheel to bring the center of gravity of the load to the right or left of the supporting trunnions as the case would require, the releasing pin is then withdrawn, when the worm drops out of gear, allowing the swinging platform to go by the run until it strikes the rail of the track and the rock slides off the box. As soon as the load is discharged from the box, the swinging platform rights itself and is easily brought to a horizontal position, as the center of gravity of the empty swinging platform is below the trunnion bolts. The hand-wheel shaft is then raised, the worm engaged in the worm gear, and the releasing pin pushed back, keeping it in position.



Rock Dump Car Unloading.

## OVERHEAD CHARGES IN VALUATION—EXAMPLES OF PERCENTAGES ALLOWED IN VARIOUS WELL KNOWN APPRAISALS.

Courts and public service commissioners, by their recent decisions, have recognized that "Overhead Charges" should properly be added to the construction costs of the property in order to determine its reproductive value. There is, however, a difference of opinion between these bodies as to what should be termed "Overhead Charges" and what percentage should be allowed to cover the same. In a paper in the October Aera, the official publication of the American Electric Railway Association, Mr. P. J. Kealy, President Kansas City Ry. Co., and member of the A. E. R. A. valuation committee, gives the following examples of "overhead charges" selected at random from various appraisals made during the last 10 years:

**Railroad Commission of Wisconsin.**—The Engineering Department of the Railroad Commission of Wisconsin has almost uniformly allowed the following "Overhead Charges" in its valuation work:

| | Per cent |
|---|---|
| Engineering and superintendence | 4 |
| Organization and legal | 2 |
| Interest during construction | 4 |
| Contingencies | 2 |
| Total | 12 |

**Chicago Elevated Railways.**—In his appraisal of the Chicago Elevated Railways, Prof. Geo. F. Swain added 30 per cent for "Overhead Charges," including engineering, legal expenses, contingencies, taxes, insurance, administration, promotion, organization, interest during construction and brokerage. The Valuation Committee, consisting of J. J. Reynolds, John Ericson, E. C. Shankland and Geo. Weston, added 18 per cent for "Overhead Charges" to cover substantially the same items.

**Metropolitan Street Railway Co. of Kansas City, Mo.**—Total value approved by Judge Wm. C. Hook, and the Missouri Public Service Commission. In his appraisal of this property, Mr. Bion J. Arnold added an average of 11 per cent to cover the cost of organization, engineering and incidentals. In addition thereto, 3 per cent was allowed as carrying charges and 2 per cent for general legal and organization expenses. Also 5 per cent was allowed for the cost of financing. The total "Overhead Allowance" being 22.3775 per cent.

**Kansas City Electric Light Co.**—In the appraisal of this property, an average of 9.6 per cent was added to cover the cost of engineering, organization and incidentals. In addition thereto, 6 per cent was allowed as carrying charges, 1 per cent for general legal and organization expenses, and 3 per cent for contingencies which included insurance and taxes during construction. Also 7.5 per cent was allowed as the cost of financing. The total "Overhead Allowance" being 29.602 per cent. In making an appraisal of this same property, the Public Service Commission of the State of Missouri, in addition to the general contractor's profit of 10 per cent, made an overhead allowance of 6 per cent for interest during construction, 1.5 per cent for taxes, 0.5 per cent for insurance, 1 per cent for legal, 5 per cent for engineering and 2 per cent for contingencies, making a general "Overhead Allowance," exclusive of an allowance for contractor's profits, of 16 per cent.

**Chicago Surface Lines.**—Appraisal made by Messrs. Bion J. Arnold, M. E. Cooley and A. B. Du Pont. Interest during construction, legal expense, contingencies and brokerage, 10 per cent. Organization, engineering and incidentals, 11 per cent. Total "Overhead Allowance," 21.7 per cent.

**Chicago Consolidated Traction Co.**—Appraisal made by Mr. Bion J. Arnold and Mr. Geo. Weston. Organization, engineering and incidentals, 14.6 per cent. Legal expense, interest during construction and contingencies, 5.8 per cent. Expenses incident to conducting the work, furnishing equipment and brokerage, 18 per cent. Total "Overhead Allowance, 38.4 per cent.

**Cleveland Railway Co.**—Decision by Judge Robert W Taylor. Specific "Overhead Charges" to cover contingencies, uncertainties, purchasing and handling, 5.88 per cent. General "Overhead Charges" to cover financing, engineering, legal expense, organization, administration, insurance, superintendence, interest during construction, delays not covered by specific allowances, cosents, litigation with property owners, incidentals and contingencies, 16.30 per cent. Total "Overhead Allowance," 22.18 per cent.

**Puget Sound Electric Ry.**—Appraisal by the Washington Railroad Commission. Total "Overhead Allowance," including engineering and superintendence, supervision and management, contingencies, legal and general expense and interest during construction, 19 per cent.

**Michigan Railroad Appraisal.**—Appraisal made by Prof. M. E. Cooley.

| | |
|---|---|
| Value of the physical property above, exclusive of any "overhead charges" | $170,291,556 |
| Overhead allowance | 32,424,706 |
| Total | $202,716,262 |

| | Amount. | Per cent of structural cost. |
|---|---|---|
| Engineering | $ 5,386,772 | 3.2 |
| Contingencies | 18,128,759 | 10.8 |
| Legal | 673,349 | 0.4 |
| Interest during construction | 5,290,549 | 3.1 |
| Organization | 2,645,277 | 1.5 |
| Total | $32,424,706 | 19.0 |

**Minnesota Railroad Appraisal.**—Appraisal by Mr. D. C. Morgan, Engineer of Commission.

| | |
|---|---|
| Physical property, exclusive of "overhead charges" | $345,260,419 |
| Overhead allowance | 61,264,765 |
| Total | $406,525,184 |

| | Amount. | Per cent of structural cost. |
|---|---|---|
| Engineering, superintendence and legal expense | $12,133,642 | 3.5 |
| Contingencies | 17,869,703 | 5.2 |
| Interest during construction | 31,261,420 | 9.0 |
| Total | $61,264,765 | 17.7 |

**Des Moines Water Co.**—Value fixed by Judge Smith McPherson:

| | |
|---|---|
| Physical property, exclusive of "overhead charges" | $1,452,092 |
| Overhead allowance | 233,856 |
| Total | $1,685,948 |

| | Amount. | Per cent of structural cost. |
|---|---|---|
| Engineering, superintendence and general legal expense | $116,928 | 8.0 |
| Interest during construction | 116,928 | 8.0 |
| Total | $233,856 | 16.0 |

**New York, New Haven & Hartford R. R.**—Appraisal made by Prof. Geo. F. Swain.

| | |
|---|---|
| Inventory reproduction cost | $259,635,934 |
| Overhead allowance | 40,333,824 |
| Total | $299,969,758 |

| | Amount. | Per cent of inventory cost. |
|---|---|---|
| Engineering | $ 5,574,038 | 2.2 |
| Contingencies | 5,574,039 | 2.1 |
| Interest and brokerage | 23,554,678 | 9.0 |
| Legal expense | 2,475,389 | 1.0 |
| General expense | 3,155,680 | 1.2 |
| Total | $40,333,824 | 15.5 |

**Coney Island & Brooklyn R. R.**—Decision by Public Service Commission of New York. Total "Overhead Allowance," including contractor's profit, engineering, organization and incidentals, 24.81 per cent.

**Coney Island & Brooklyn R. R. Co.**—Appraisal by Mr. Frank R. Ford.

| | Amount. | Per cent of physical. |
|---|---|---|
| Physical property | $6,558,447 | .... |
| Promotion and legal expense | 421,200 | 6.42 |
| Property owners' consents | 278,500 | 4.25 |
| Organization expense | 195,640 | 2.98 |
| Incidentals | 276,460 | 4.22 |
| Engineering expense | 230,792 | 3.52 |
| Contractor's profit | 527,514 | 8.04 |
| Interest and taxes | 561,345 | 8.56 |
| Totals | $9,049,898 | 37.90 |

**Detroit United Ry.**—City Lines. Appraisal by Mr. Robert B. Rifenberick.

| | | Per cent of structural. |
|---|---|---|
| Material and labor | $18,663,536 | .... |
| Incidentals | 1,050,294 | 5.62 |
| Contractors' profits | 1,148,777 | 6.16 |
| Liability insurance | 114,264 | .61 |
| Builder's risk | 17,243 | .09 |
| Architect's fees | 62,551 | .34 |
| Cost of acquiring land | 79,463 | .43 |
| Engineering | 720,955 | 3.86 |
| Organization | 1,092,122 | 5.85 |
| Carrying charges | 2,064,111 | 11.06 |
| Financing | 1,999,894 | 10.72 |
| Total | $27,013,210 | 44.74 |

## ROCK WORK ON THE STORM KING HIGHWAY, CORNWALL, N. Y.

Contributed by H. E. Hicks.

Construction work is being pushed on the Storm King Road, the final link in the New York State Highway between New York and Albany. It extends a distance of 4¼ miles between West Point and Cornwall, N. Y. For practically the entire distance the road is a side hill cut around Crow Nest and Storm King Mountains. It directly overlooks the Hudson River and reaches at its highest point an elevation of 400 ft. above sea level.

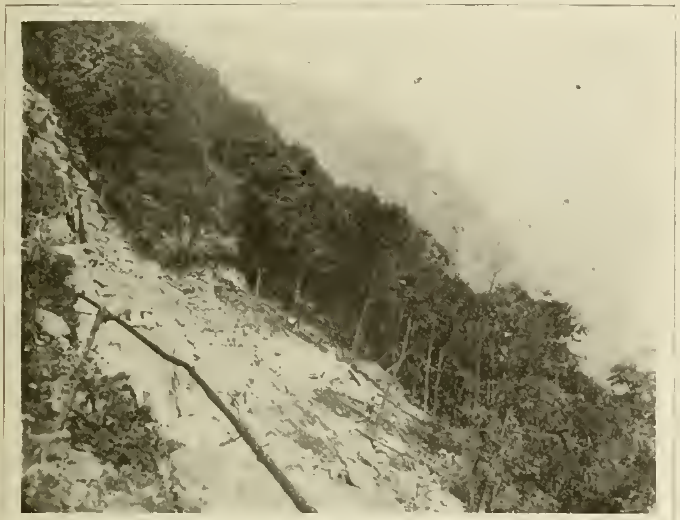


Fig. 1—A Working on Crow Nest Mountain, Showing Dry Wall Under Construction.

The mountain sides are very steep and inaccessible and road building presents many difficulties. The excavation work required totals 60,000 cu. yd. of rock and 80,000 cu. yd. of earth and boulders. The rock is a bastard granite and the boulders vary in size up to 250 cu. yd. There are seven gangs at work in four different places, making the cut and building the retaining wall. This is from 10 to 50 ft. in height, from 3 to 8 ft. being laid in mortar and the balance dry masonry, completed by a rustic stone parapet. Stones for the wall are placed by four hoists and two cranes. The balance of the handling and hauling is done by hand and, at one working, by mules.

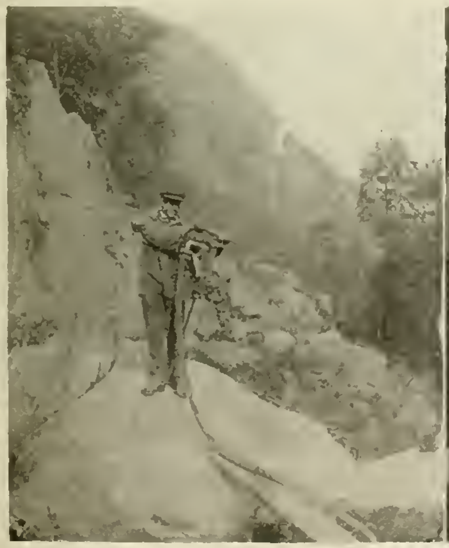


Fig. 2—Jackhamer Drilling at an Awkward Angle on a 200 Cu. Yd. Boulder.

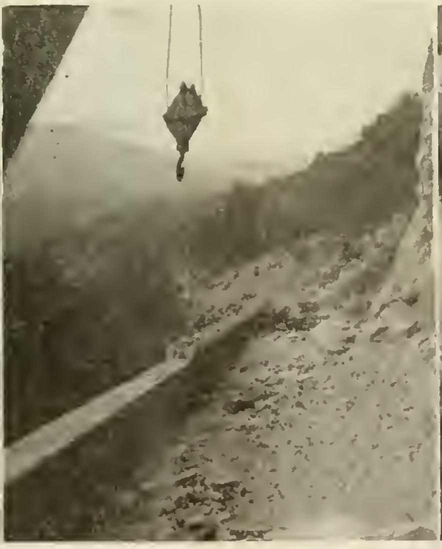


Fig. 3—A Portion of the Rough Graded Roadway, Showing Retaining Wall.

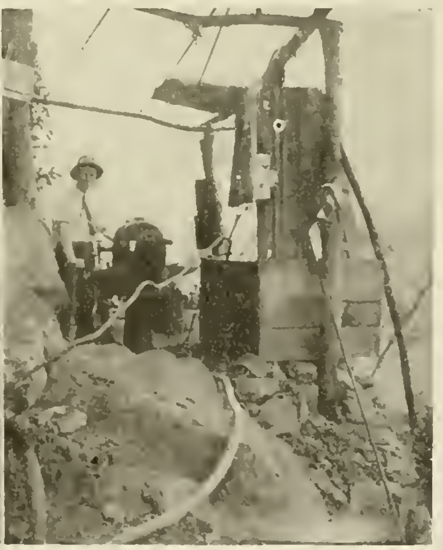


Fig. 4—Leyner Drill Sharpener Installed on Edge of Cliff at Storm King Mountain.

Drilling for excavation and for anchoring the retaining walls is done by Jackhamers, of which there are 12 in use. These hand drills are giving a good account of themselves although the duty is a severe one. Much of the work is done in places and at angles which make it impossible for the drill runner to properly hold his machine. In fact, it is quite common for the drill to support the man instead of the man holding the drill. In drilling the cliff at Storm King, where the cut rose a sheer 150 ft. above the road bed, the workmen drilled while suspended in a harness of heavy canvas bands. Unfortunately for the contractor this portion of the work was brought to a standstill at a time when the Jackhamer operators had been working in mid-air long enough to have become accustomed to it and to have reached their maximum efficiency. A stone company, whose unused crusher plant, lying at the foot of the cliff was damaged by falling rock, obtained an injunction indefinitely halting work at this place.

Cross bits are used at all workings. Sharpening is done both by hand and by a Leyner sharpener. The latter is mounted on the edge of the cliff with scant protection from the elements. It is used for shanking as well as sharpening. Air for operating the Jackhamers and hoists at all workings is piped from a plant at the Cornwall end of the contract. This air compressing plant, a 1,400 cu. ft. Imperial short belt, electric motor driven machine, was purchased, as it stands from the Oscar Daniels Co., who had recently completed the Moodna Siphon of the Catskill Aqueduct. The air line follows the track of the West Shore R. R. at the foot of the mountains. There is 500 ft. of 6-in., 300 ft. of 4-in. piping, the balance being of 2-in. diameter. All branches from this main air line to the working places are of 2-in. pipe.

Considerable trouble is experienced from rock falling on the railroad tracks. The contractor maintains a locomotive crane on a siding at the foot of each mountain, although the rock that comes down is usually small enough to be removed by hand. At the time the writer's visit a flying fragment, striking a telegraph pole, broke it in half. At other times rails have been broken.

The John L. Hayes Construction Co. of Cornwall, N. Y., is building this road under the personal direction of Mr. John L. Hayes. Mr. A. C. Perkins is superintendent, assisted by Mr. J. J. O'Neill.

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## COMPARATIVE COSTS OF MINE HAULAGE BY HORSES AND COMPRESSED AIR.

Actual cost figures for mine haulage by horses and by compressed air are given by Ravul Green, of the Rocky Mountain Branch, Canadian Mining Institute, in the September Compressed Air Magazine, from which the matter that follows is taken:

The following comparisons only apply to mines working under the following conditions: Seams pitching 25 degs. or more; pit cars containing two or three tons; rails weighing 30 to 40 lb. per yd.; grades fluctuating but little from 0.46 to 1.00 per cent in favor of the loads; gangways roomy; tracks fairly well kept; curves few and slight.

### Compressed Air Haulage.

An average summer month of 1915 was chosen for the test. The output was 33,826 tons, and the number of haulage shifts 19.5. All expense chargeable to haulage, including work done on idle days, holidays and Sundays, has been allocated to that item. Two hundred 3-ton steel cars were in use, equipped with 18-in. Hadfield wheels. The gangway was laid with 40-lb. rails. Besides the morning haulage shift, an afternoon and a midnight shift were employed. Only sufficient drivers were occupied on the midnight shift to fill all cars in preparation for the day shift, besides handling such supplies and material as are always needed in a coal mine. These extra hands being chargeable to haulage, tend to increase costs, especially if there are many idle days. All locomotives were of the H. K. Porter standard compound type. The haulage comprised two operations: Firstly, the gathering or loading from the mine chutes, and haulage to a main parting—the trips consisting of some 10 to 20 cars, with 6-ton locomotives; secondly, the haulage of 40-car trips, from the main parting to the tipple approach, by the use of 9-ton locomotives.

The monthly expenses amounted to:

| | |
|---|---|
| Track cleaners, drivers, trackmen, etc. | $2,335 |
| Power house labor | 599 |
| Material repairs cars, boilers, locomotives | 426 |
| Coal and other supplies | 1,238 |
| Total | $4,598 |

In order to obtain an accurate account of depreciation costs, the following items were taken from the equipment ledger:

| | |
|---|---|
| Charge haul (being 50 per cent proportion of $26,690 cost of boilers, pumps, heaters, and headers) | $ 13,345 |
| Two compressors | 25,000 |
| Eight locomotives | 28,300 |
| Pipe lines | 12,800 |
| 200 cars | 30,000 |
| Boiler and power house at 50 per cent proportion charge haul | 5,000 |
| Total | $114,445 |

Depreciation at 11 per cent per year would equal $1,048 for one month.

Ton miles handled for the month were 70,260. The cost per ton mile per item was:

| | |
|---|---|
| Mine labor | $0.033 |
| Power house labor | 0.007 |
| Material repairs labor | 0.006 |
| Coal and other supplies | 0.017 |
| Equipment, 11 per cent | 0.015 |
| Total | $0.078 |

If a full month's run had been realized, that is, if the shipments had reached, say, 41,000 tons instead of 33,000, the theoretical cost would have been $0.060 instead of $0.078. However, it is doubtful if this figure would be reached in practice, as it is based on all the costs decreasing in the same ratio as the tonnage increases, which, in this case, is obviously untrue. For example, the mine labor, the material repairs, and the supplies increase practically in the same ratio as the tonnage. Again, the power house and equipment accounts are more or less fixed in their total, whatever the tonnage. Probably $0.070 would be a very conservative figure to take in such an instance.

### Horse Haulage.

The details of conditions under which the test was carried out were: Total tons shipped during the month, 15,573; days haulage worked, 25. The cars were steel framed, wooden boxes, of 2-ton capacity, 18-in. Hadfield wheels; rails, 40 lb. to the yard; tracks in fair condition—no sharp curves; grade quite uniform, averaging 0.5 of 1 per cent in favor of the loads. An afternoon shift of drivers was employed in order to prepare a full string of loaded cars for the morning shift. Good heavy horses were used. The haulage consisted of two operations: First, hauling from the mine chutes by single horses to a main parting; second, hauling from the main parting to the tipple approach by means of a three-horse spike team, 20 to 25 pit cars composing a trip.

The monthly expenses amounted to:

Track cleaners, drivers, helpers, $884.

Repairs to cars, etc., $164. Supplies and attendance on 22 horses, $330. Depreciation charges: For horses this figures as follows, averaging over a period of five years: Total horses owned, 83, value $16,600. Less horses killed, 20, value $4,000; loss on 28 horses sold, $3,560; loss on value of balance, $3,500; total, $11,060. Loss in five years, 66 per cent, or 13 per cent per year.

Depreciation on horses: 22 horses at $200 each equals $4,400 at 13 per cent yearly, for one month equals $48. Depreciation on equipment: 130 pit cars at $110 each equals $14,300; stables, stable equipment, tools, $2,966; total, $17,266. Depreciation at 11 per cent per year equals monthly $167.

The total monthly expenses are therefore as follows: Labor, $1,048; supplies, $330; depreciation horses, $48; depreciation equipment, $167; total, $1,593.

Total ton miles hauled, 14,450.

COMPARISON PER TON-MILE.

| | Compressed air. | Horses. |
|---|---|---|
| Labor | $0.046 | $0.072 |
| Supplies | 0.017 | 0.022 |
| Depreciation | 0.015 | 0.015 |
| Total cost | $0.078 | $0.109 |

The conclusions to be deduced from the above facts are that: First, compressed air haulage is about 3 ct. per ton cheaper than horse haulage; second, cost of supplies and depreciation are about the same in each case; third, compressed air permits of from two to three times as much coal (in certain cases probably more) being handled than by horse haulage; fourth, the main reason for lower cost by compressed air is due to the labor item, in this case about 3 ct. per ton; fifth, the total of 7/8 ct. per ton for compressed air haulage could undoubtedly be reduced to 7 ct. for a month of 25 working days.

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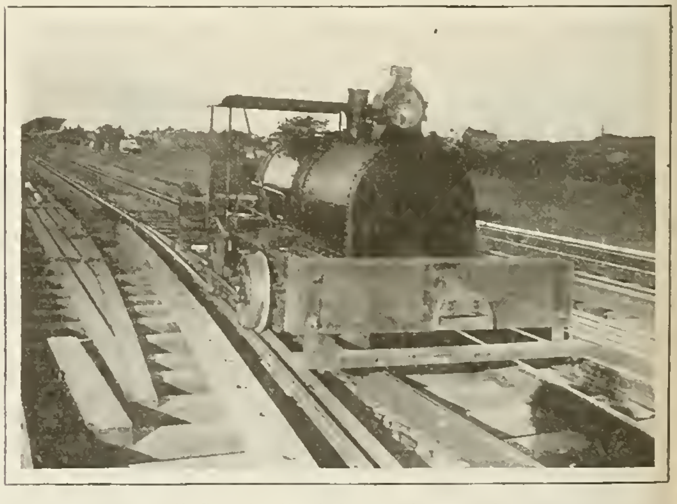
## NEW TYPE STANDARDIZED LIGHT LOCOMOTIVE.

A new type standardized steam locomotive, of particular interest to contractors, has recently been placed in the market by the Bell Locomotive Works, Inc., New York City. The machinery or engine parts are all confined to one unit so small and compact that it can be installed in the narrowest gage locomotives. The engine unit includes such features as roller bearings, drop forged parts throughout and the highest grade material and workmanship. All working parts are enclosed in an oil tight, dust proof case.

The boiler is of the horizontal type with shell and fire box head of one piece of pressed steel and smoke box head welded in. The shell is wound with several layers of piano wire, thus giving it great strength without excessive weight. The tubes are expanded into the front head and brazed into the rear head from the inside of the boiler by a patented process.



Bell Standardized Steam Locomotive.

The fire is so distributed that it gives maximum heat to the lower tubes and only a comparatively low heat to the tubes above the center of the boiler or those tubes not under water. In other words, there are tubes where stay bolts are usually employed and this feature gives superheated steam without the addition of super-heaters. There are no stays, seams, or rivets.

The boiler plant is extremely compact, absolutely safe easily cleaned and so designed that all the tubes may be removed and replaced in one unit when necessary in from one to two hours' time. A steam pressure of from 300 to 350 lbs. is carried and at this pressure the factor of safety is 10 at least. The boiler may be fired from cold in from 10 to 30 minutes, or fired instantly after a one or two hours' stand.

The locomotive will run on any fuel from gasolene and kerosene to crude oil, or coal or wood and will give no smoke or sparks when burning kerosene or fuel oil. It can be started quickly and is stated to have the speed of the direct connected locomotive combined with the power of the geared locomotive.

These locomotives are now built in sizes from 2 to 14 tons and plans are being made to build them in very much larger sizes.

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## SOME DATA ON THE TOWER FOUNDATIONS FOR A TRANSMISSION LINE BETWEEN NIAGARA FALLS AND TORONTO.*

The following data apply to the tower foundations of the two 60,000-volt transmission lines of the Toronto Power Co., extending from Niagara Falls to Toronto.

**Types in Use.**—The types of foundation in different soils used for the standard 40-ft. tower are shown in Fig. 1. About 100 sets of these footings have been dug up after having been in use for seven years. In no case has the galvanizing on the members deteriorated, and, with a few exceptions, the 3x6x24-in. impregnated wooden blocks were in a fair state of preservation. The type of foundation shown in Fig. 1 (b) has no wood base, and was designed for use in hard pan; that shown in Fig. 1 (c) has a wood base, with filling and galvanized pipe as noted, this type being used in marsh land; while the type shown, in Fig. 1 (d), has a wood base, and was designed for loose soil.

In another type of tower the foundations contained no impregnated blocks, nor were any precautions taken to prevent corrosion of the steel, except the hot galvanizing. Six of these towers were erected in low, marshy black-muck, in which there was no resistance to borings driven to a depth of 40 ft. In this type 2-in. plank sheeting was driven around the site of each tower leg; the muck was then dug out; and a floating foundation built 6 ft. below the ground surface. This foundation consisted of impregnated 2-in. planking, the footings being set in concrete. About 1 cu. yd. of concrete was placed around and under each stub, the excavation being 30x30-in. x 6 ft. deep. These towers have been erected for one year, and they have neither settled nor deviated from alignment.

Great care was taken in locating these towers to avoid, wherever possible, soft, marshy soil, and also to equalize the grade. It has been found that tower footings in gravel, or in a mixture of sand and loam, packed tightly, offer great resistance against an upward pull.

A number of towers of the second type were founded on a thinly stratified rock, which could easily be excavated to a depth of 3 ft. The stubs were cut to 3 ft. 6 in., and were set in a 1:4 concrete mixture. This construction has proved satisfactory.

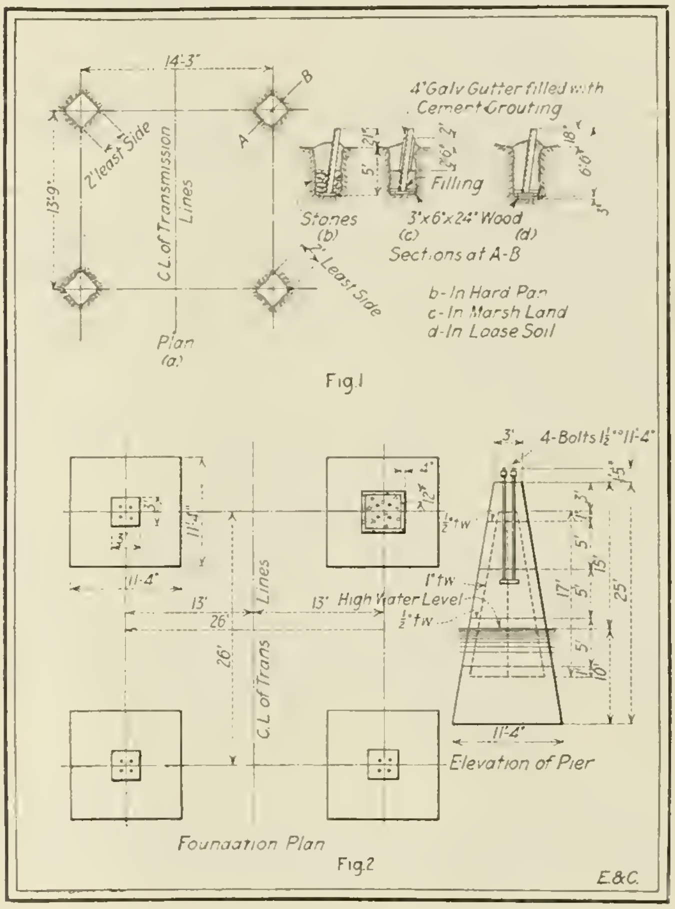
**Foundations for Narrow-Base Towers.**—For a type of narrow-base latticed tower the foundations were built in two ways, as follows:

(a) A foundation of 1:3:5 concrete, 6x6x6 ft., was constructed and provided with twelve 1¼-in. anchor bolts 5 ft. 6 in. long.

(b) Foundations, 6x6 ft. and with variable depths, were constructed, these foundations being built in the following manner: The site was first excavated; a copper grounding-ribbon was then placed; and finally 12 in. of 1:3:5 concrete were placed and tamped. No anchor bolts were used, but the tower was erected on this 12-in. base, and the excavation then filled with 1:3:5 concrete. This method was used on account of the variation in the dimension of the tower bases, the minimum depth of which was 6 ft.

Eleven footings were constructed in the waters of Lake Ontario, at Burlington Beach, Ont., the mean depth of water being 3 ft. A double cofferdam was first built of 2x8-in. tongue-and-groove spruce, driven to a depth of 10 ft. below the lake bottom by a small steam hammer. The water was then pumped out, and the sand and gravel excavated to a depth of 6 ft. below the lake bottom, where very coarse gravel was encountered. The foundation was then constructed according to the plan shown in Fig. 2, the spruce sheeting being left in place to prevent scour. After a foundation was completed a wall of 10-in. stones, each piece weighing from 500 to 1,500 lb., was built around the two outer footings of each foundation to afford extra protection, the location of these towers being near the shore where storms from the east are prevalent.

In setting the stubs a template was used with success. This template, which was carried by the setting gang, was lined up on the center line stakes, then leveled by the foreman, by means of a carpenter's level, and finally blocked up and checked. The stubs were bolted to the template and the filling in of holes then proceeded with, one man placing the backfilling while two men tamped the material. Where water was available it was used to settle the backfilling.



Details of Tower Foundations.

**Erection of Towers.**—The towers were assembled at the locations where they were to be erected. From eight to twelve towers were erected in one day by eight men and one team. The sheer-leg method was found to be the most efficient, except where cramped for room, when the gin-pole was used to best advantage. This decision was reached after the use of sheer-legs, derricks and gin-poles.

The sheer-legs used on this work were constructed in the following manner: Two pieces of 6x8-in. clear Georgia pine, 34 ft. long, were bolted together 14 in. from the top with a 1-in. bolt 14 in. long. This sheer-leg, equipped with a set of 12-in. triple blocks, hand lines, anchor pins, etc., made a cheap and serviceable erecting outfit. It was used in the erection of a line of 928 towers, averaging 2¼ tons each, with only one accident, this being due to negligence on the part of the foreman in connection with the erection of the first tower.

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*From paper by F. C. Connery before convention of American Institute of Electrical Engineers.

**Use of Guy Anchors.**—Patent anchors for guying should not be used except for light construction. In light soil, the old-fashioned slug, or deadman, gives the best results. All guys should be tested periodically and tightened up. Where there are more than one guy on a pole, galvanized turnbuckles should be used to obtain the best results. From observations extending over 10 years the writer states that fully 40 per cent of the guys in use are inefficient, this condition being due to lack of inspection. The anchor should be placed at a distance from the base equal to one-third of the height.

In using rock bolts for anchoring care should be taken, if the rock is covered with a layer of earth, to place the anchor so that the ring is just above the rock surface, and then to fasten a long link to the ring, guying to this. This method gives much better results than if the ring had been left above the ground surface and the guy attached to it, as the anchor rod will bend in the latter case. The rock bolts should be grouted in with hot brimstone.

The company is designing tower footings which include the following features:

(1) A modification of an ordinary screw-type guy anchor, similar to the "Matthews" or "Stombaugh" anchor, with the top of the anchor rod shaped to take the tower leg; this for towers of light windmill type.

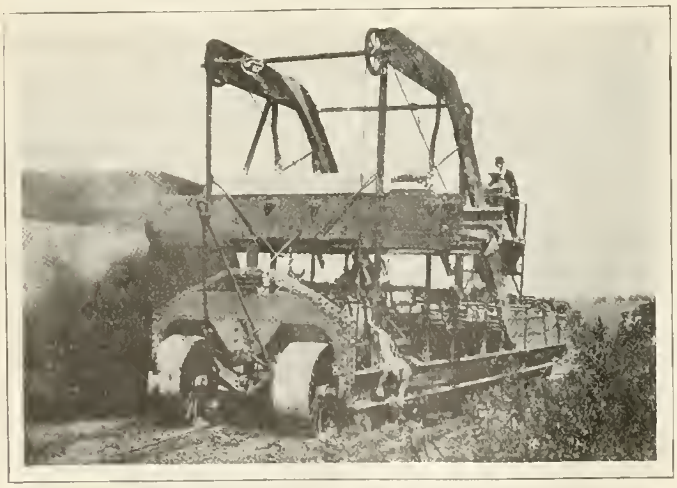
(2) For heavy anchor, long-span, towers, etc., a large foot plate supported on a shallow concrete footing sufficient to give a good bearing, and an anchor similar to those mentioned above, with the exception that the end of the bolt will be threaded to take a nut and locknut.

(3) For extra heavy, or four-circuit towers, a large section screw pile with top plate to which the tower footplate can be bolted.

The question of threading an ordinary wooden pile is also offered for consideration. There are locations on almost every line where marshy land is encountered, and it is usually a very expensive operation to use a pile-driving outfit in these locations. In connection with this method it has been found that it is not necessary to drive a pile to refusal to obtain a good footing for a standard tower, as there is sufficient skin friction developed by the pile in the upper layers of the ground to give satisfactory results. Twenty-five-foot piles have been found satisfactory in very swampy ground, where borings had been taken to a depth of 40 ft. without striking firm soil.

## A NEW TYPE OF EXCAVATOR.

A new type of excavating machine has been used during the present season in road grading in Hardin County, Iowa. The accompanying illustration, reproduced from the Service Bulletin of the Iowa State Highway Commission, shows some of the features of the excavator.



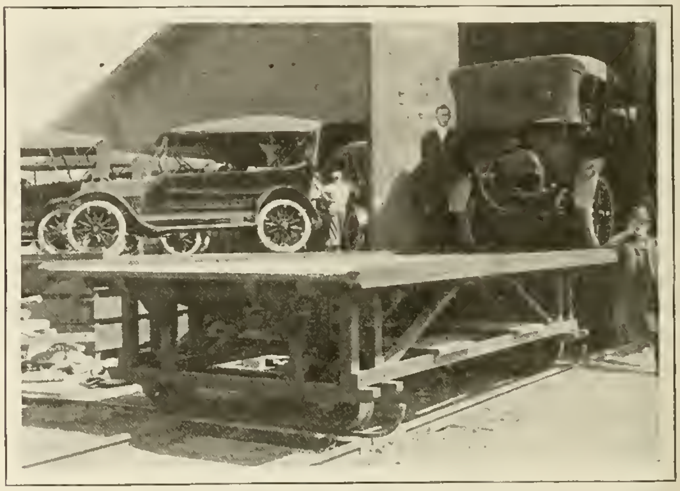
Excavator Grading Road in Hardin County, Iowa.

A steam engine in front, not shown in the picture, and a small automobile engine located where the men are seen on the machine together furnish the power which moves the machine and performs the various operations. As the machine is pulled forward by the steam engine, five large plows, not distinguishable in the picture, tear up the soil. A yard and a half shovel, shaped like an ordinary slip scraper, then picks up the loose material, lifts it to the top of the machine and dumps it in a movable hopper. This movable hopper is shown extended to the side where the material is being dropped into a dump wagon. The small engine operates the movable hopper.

The machine was designed, patented and built by L. C. Wood, Alden, Ia., and is being used by him on his contract with Hardin County. This contract calls for about 82,000 cu. yd. of excavation at 18 ct. per cubic yard.

## A DEVICE FOR LOADING AND UNLOADING AUTOMOBILES FROM END DOOR BOX CARS.

A movable platform arrangement is used at Riverside, Cal., and other points on the Santa Fe Ry. to facilitate the unloading of automobiles or other commodities. The device has a pair of movable rails which are placed on top of the regular track so that platform can be moved out to the car.



Automobile Unloading Platform.

When not in use the device stands locked in a recess in the platform which it serves and is a part of that platform. When in use and a car which is to be unloaded is spotted, the platform is unlocked, its rails adjusted, and it is pushed out to serve the side or end door of the car which has been placed to be loaded or unloaded. After the automobile or other commodity has been removed from the car onto the device and the device has been pushed back into its recess, the automobile or other commodity is then rolled off onto the main platform. When two or more care are to be unloaded, one car can be spotted on each side of the device and while one car is being unloaded the other can be prepared for unloading, thus making an additional saving in time. This condition can be extended in like manner over as many tracks as is cared to operate over.

The arrangement was devised by Mr. B. J. Simmons, Division Engineer of the Santa Fe, and J. H. Bauman, Agent at Riverside, and application has been filed for a patent by these parties.

## THE $3,000,000 GARBAGE DISPOSAL PLANT OF NEW YORK CITY.

Construction is now underway on what is stated to be the largest garbage reduction plant in the world. The plant will have a capacity of over 2,000 tons of garbage per day. It is being constructed and will be operated on its completion by the Metropolitan By-Products Co. It will take care of all the garbage collected in the Borough of Manhattan, the Bronx and Brooklyn. The Cobwell process will be used in this plant. The following description of the plant is taken from a paper presented on Oct. 11 at the convention of the American Society of Municipal Improvement by Gustave R. Tuska, Consulting Engineer, New York City:

The garbage will be delivered at the plant in barges, so constructed that all water drained from the garbage in transit will be collected in a special closed tank located at one end of the barge. On the arrival of the barge at the plant these tanks will be automatically emptied by attaching a steam connection thereto and by means of the steam pressure blowing the drained water to tanks on shore; the steam also acting so as to disinfect the tanks. While in transit the barges will be covered by specially treated waterproof canvas covers so attached as to prevent the discharge of any of the garbage from the barges.

A canvas apron will extend from the barge to the dock to prevent any of the garbage falling into the water during the unloading of the barge. This apron is so designed that it will automatically move with the barge when the same is moved along the bulkhead to bring the various portions of the load under the hoist.

The garbage will be unloaded from the barges by two steam operated hoists, equipped with grab buckets. These grab buckets will deliver the garbage to closed conveyors of the steel scraper type which will convey the material to the reducers, located in the main building.

This main building is 200 ft. by 330 ft. and about 30 ft. high and of one story. This building contains the reducers, 250 in number, with the necessary conveyors (all of which will be of closed type) for the raw garbage, and for the dried tankage, also the piping for steam and solvent and the transmission machinery. The capacity of each reducer unit is from 8 to 10 tons of raw garbage per 24 hours, depending on the steam pressure employed. In the New Bedford and Los Angeles plants the capacity obtained from one unit is 8 tons per 24 hours, with a steam pressure of 70 lbs. Here the steam pressure has been increased to 150 lbs., thereby raising the temperature for de-hydration from 320° F. to 360° F., thereby increasing the capacity of the reducer. An increase in the capacity has also been obtained through the change in solvent. In other plants using this process gasoline is employed but in this plant there will be used a special solvent, which is a kerosene distillate obtained by use of a vacuum still, which distillate will be made at the works. A further economy will be obtained by so designing the circulating system as to return condensed water at 360° F. to the boilers.

Heretofore only surface condensers have been employed in the plants using this process but after a considerable amount of experimental work with jet condensers, it has been proven that the latter are more satisfactory as well as more economical. It has therefore been decided to use the jet type of condenser in this plant.

The grease with the distillate is piped from the main building to the stills which are of the vacuum type and the distillate there taken from the grease, condensed and delivered to the solvent storage tanks and the grease to other storage tanks. The "grease" building where this work is done is 100 ft. long by 100 ft. wide and 25 ft. high. The dried tankage is conveyed by belt conveyors from the main building to the grinding and screening building.

Pan mills and rotary screens are employed. From the screening building the tankage is conveyed to the storage building which is 100 ft. long by 100 ft. wide and 40 ft. high. The material is distributed throughout this building by screw conveyors. The tunnels will be built through this building containing belt conveyors to automatically convey the stored material to the loading vessel through swivel spouts.

The boiler house with an engine room extension will be 140 ft. long by 50 ft. wide and 65 ft. high. Water tube boilers with automatic underfeed stokers will be used with a productive capacity of 7,500 boiler horsepower.

The plant will also comprise a machinery building 30 ft. by 160 ft. by 25 ft., containing pumps of a capacity of 21,000 gals. per minute. Also boiler, blacksmith, machine and pattern shops and storeroom, etc.

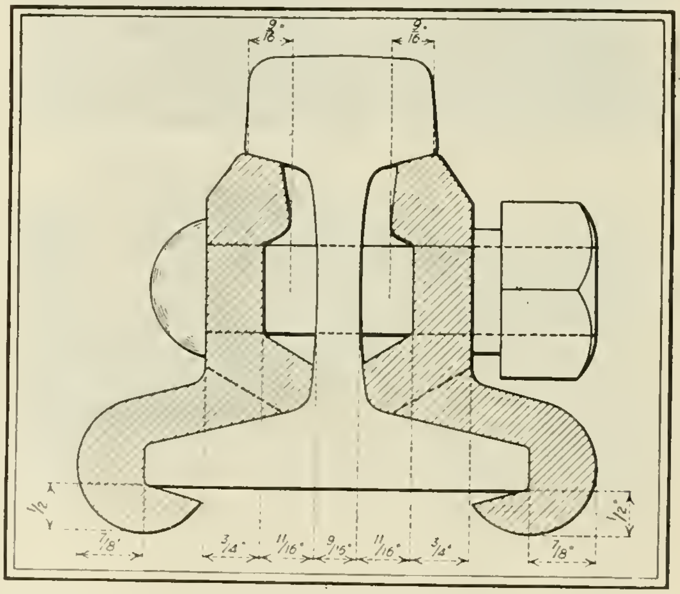
The storage tanks will have a capacity of 400,000 gal. of solvent, and 14,000 bbl. of grease. There will also be constructed the necessary administration building, mechanics' dormitory building, etc., etc.

The estimated cost of this plant when completed for a capacity of 2,000 tons of garbage per 24 hours is $3,000,000, the main items of which are as follows:

| | |
|---|---|
| Buildings | $ 500,000 |
| Boiler plant, including concrete stack | 190,000 |
| Reducer units, including condenser, still and auxiliary equipment, at $7,000 each for 250 | 1,750,000 |
| Piping | 250,000 |
| Conveyors | 125,000 |

## NEW TYPE OF RAIL JOINT.

A new rail joint, designed to reduce the batter on rail heads and to eliminate the chafing of the rail ends in the rail joints is now being tested. Instead of having a wedge shaped bar or girder support, the new joint is designed to throw the weight or wheel load directly from the head of the rail to the juncture of the web and the flange, which allows the angle bar to grip the rail in a vice-like fashion. The center part of the bar has a flare, which extends over the top and the outer edge of the flange where it locks the angle bar against rotation except as wear takes place on the bar at the bottom of the flange and on the top of the bar at the under side of the head of the rail. By tightening the bolts the lost motion is taken up without stretching or straining the material in the bars, thereby relieving all lost motion and keeping the rails perfectly true and level perpendicularly and laterally. The bearing at the juncture of the rail web and flange, which extends the full length of the bar keeps the rail ends from moving laterally and by the adjustable device the rail ends are kept from moving vertically. This device at the center of the bar is assisted in its functions in having the bar cut away or weakened from the center part to the ends of the bar, which allows elasticity of the joint, and, as the wheels pass over the joint instead of bending the rail ends over each joint tie individually the wave motion is allowed to go through the joint naturally, there only being a stiff part of about 6 in. over the center of the joint or rail juncture. This allows no hammer blow, which makes the joint smooth and noiseless.



New Type of Rail Joint.

One of the joints has been in service for about 6 months on 100-lb. rails at the end of a subway, where there is a great deal of wave motion in the track, and where the traffic is about 100 trains of heaviest equipment per day. During this time the bolts have not been tightened neither has the joint been tamped up, nor does it show any sign of the rail ends chafing or sign of wear, and the bolts are absolutely tight. The joint was invented by Mr. A. L. Clapp, Chicago, Roadmaster for the Chicago & Northwestern Ry.

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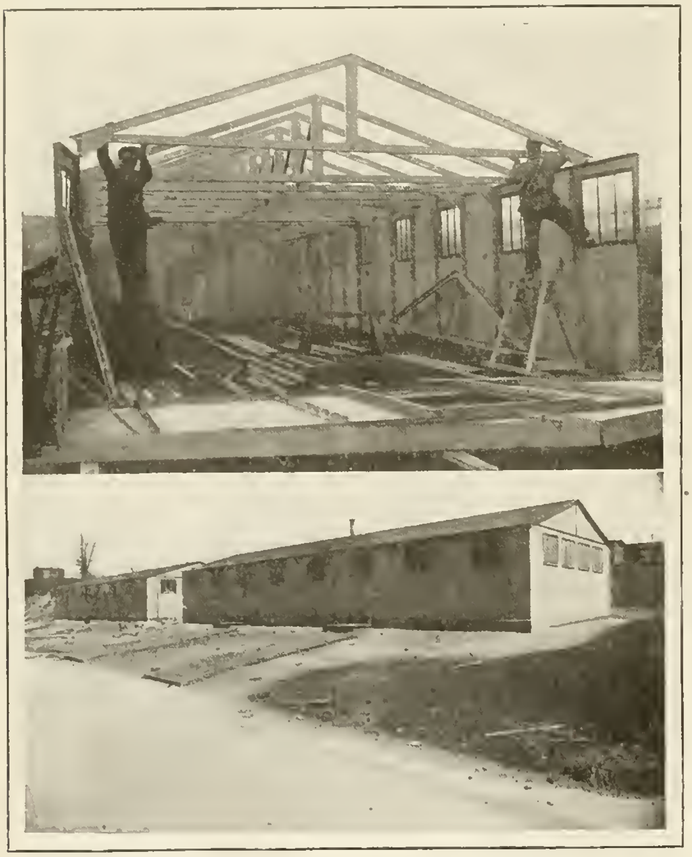
As the result of careful water waste inspection and correction, the average daily water consumption per capita in the Borough of Brooklyn, New York City, has been reduced from 97 gals. in 1910 to 76 gals. in 1915.

## PORTABLE STEEL BUILDINGS FOR CONSTRUCTION CAMPS.

On several large construction jobs portable buildings composed of steel units are being used for offices, bunk houses, shops and other camp purposes. These portable steel buildings are composed of four units—side wall panels, mullion supports between the panels, pressed steel trusses and steel roofing plates—and are put together without the use of bolts or rivets.

The panels are fabricated under powerful presses which flange both sides, top and bottom—at the same time paneling the steel for added rigidity. The flanges are punched so that holes come at set intervals and coincide with holes in the strengthening mullion; side wall panels are placed side by side with mullions between and locked with a wedge and bolt in a connection that is as tight as could be gained with rivets or bolts. On centers of 8-ft. trusses are locked in the same manner to the side walls and flanged steel roofing plates locked to the trusses.


Upper View: Truss Ready to Drop Into Place. Lower View: Completing Portable Steel Building.

United Steel ventilated sash panels may be used in place of any solid panel, or doors placed at any point in the building. Structures up to 40 ft. in width and any length desired may be built up of these four units.

These portable steel structures also are being used for factories, store houses, fabricating mills, in fact they are being built up under every condition where a 1-story building can be used—in structures ranging from 200 to 12,000 sq. ft. of floor space. They are manufactured by the Trussed Concrete Steel Co., Youngstown, O.

## ROAD GRADING COSTS IN CRAWFORD COUNTY, IOWA.

Contracts for road grading in Crawford County, Iowa, during the present year, were let at an average price of 20 ct. per cubic yard. About 251,700 cu. yd. of grading distributed over 20.33 miles of road were contracted for this season. This is an average of 12,381 cu. yd. per mile. The lowest price paid was 17 ct. and the highest was 23 ct. The following tabulation from the October Service Bulletin of the Iowa Highway Commission gives some details of the contracts:

| Awarded to | Date. | Cu. yd. | Length, ft. | Unit cost, ct. |
|---|---|---|---|---|
| Thos. Carey & Sons, Clinton, Ia. | Apr. 12 | 11,748 | 7,834 | 22 |
| Thos. Carey & Sons, Clinton, Ia. | Apr. 12 | 6,008 | 4,200 | 23 |
| Thos. Carey & Sons, Clinton, Ia. | Apr. 12 | 10,064 | 5,900 | 22½ |
| Thos. Carey & Sons, Clinton, Ia. | Apr. 12 | 13,759 | 8,966 | 21½ |
| Thos. Carey & Sons, Clinton, Ia. | Apr. 12 | 31,219 | 11,835 | 20¾ |
| Thos. Carey & Sons, Clinton, Ia. | Apr. 12 | 12,767 | 6,454 | 21 |
| Thos. Carey & Sons, Clinton, Ia. | Apr. 12 | 3,521 | 3,100 | 23 |
| Thos. Carey & Sons, Clinton, Ia. | May 22 | 10,037 | 3,999 | 17.9 |
| Thos. Carey & Sons, Clinton, Ia. | Sept. 23 | 19,004 | 3,550 | 23 |
| W. R. Shipman, Soo City, Ia. | Apr. 12 | 36,226 | 15,790 | 18.4 |
| W. R. Shipman, Soo City, Ia. | Apr. 12 | 11,328 | 2,159 | 19.5 |
| W. R. Shipman, Soo City, Ia. | Apr. 12 | 13,412 | 5,244 | 22 |
| | | 44,662 | 15,828 | 17 |
| McMahon, Corsten & Ehlers, Manning, Ia. | May 22 | ...... | 1,533 | 22 |
| T. H. Fineran, Denison, Ia. | May 22 | 1,500 | ...... | .. |
| T. H. Fineran, Denison, Ia. | May 22 | 7,631 | 5,458 | 20 |
| Lana Const. Co., Council Bluffs, Ia. | July 3 | 18,821 | 5,491 | 20 |
| Totals | | 251,709 | 107,346 | .. |
| Total No. of miles | | ...... | 20.33 | .. |
| Av. No. of yd. per mile | | ...... | 12,381.2 | .. |
| Av. cost per cubic yard | | ...... | 20 ct. | .. |

## PERSONALS.

Sanford E. Thompson, consulting engineer, has established offices and a concrete testing laboratory at 130 Federal street, Boston, Mass.

Edwin G. Foster, heretofore assistant engineer Buffalo, Rochester & Pittsburgh Ry., has been appointed valuation engineer, with headquarters at Rochester, N. Y.

J. S. McBride, heretofore valuation engineer of the Chicago & Eastern Illinois R. R., has been appointed principal assistant engineer with headquarters at Chicago.

George W. Corrigan, heretofore roadmaster of the Southern Pacific Ry. at Hornbrook, Cal., has been appointed division engineer with headquarters at Stockton, Cal.

M. F. Clements heretofore assistant engineer of the Northern Pacific Ry. at Spokane, Wash., has been appointed bridge engineer to succeed H. E. Stevens, who has been made chief engineer.

William H. Vance, heretofore engineer of maintenance of way of the Louisiana & Arkansas Ry., with headquarters at Stamps, Ark., has been appointed chief engineer and his former office has been abolished.

Edgar F. Robinson, since 1907 chief engineer of the Buffalo, Rochester & Pittsburgh Ry., has been promoted to the position of general manager.

Albert Coope has been appointed a member of the staff of the city engineer's office of Youngstown, O., to succeed Arthur Nichols, who resigned recently to enter the School of Municipal Research in New York City.

Carl J. Rhodin, since 1911 a member of the engineering staff of the J. G. White Engineering Corp. at its San Francisco office, has resigned to open a consulting office in the Alaska Commercial building, San Francisco.

The firm of Giles & Clark, 30 Church street, New York City, engineers and contractors for diamond drilling and wash-borings, etc., has been dissolved by the retirement of Edward A. Clark, and the business, plant and equipment taken over by the Giles Drilling Co., Inc., of which Robert Giles is president.

Col. Malcolm R. Crump, F. R. S. A., consulting engineer and geologist, Bowling Green, Ky., for the last four seasons county road engineer of Warren County, Kentucky, has resigned, effective Jan. 1, 1917. His entire time will be devoted to natural asphaltic material for surfacing highways, together with oil and gas developments and reports on same.

## OBITUARY.

Andrew Germer, a well known railroad builder of Michigan, died recently at his home in Flint, Mich. Mr. Germer was roadmaster for the Pere Marquette R. R. for 35 years and for several years held a similar position with the Detroit United Rys. Mr. Germer built the railroad at Flint and the steel and concrete trestle of the Pere Marquette, also built the Pere Marquette tracks from Reed City to Ludington, from Holly to Milford, and the Pere Marquette grades, bridges and sidings included in those stretches. In the employ of the Detroit United Railways he built the Detroit, Orion & Oxford electric line to Flint and constructed the terminal at Oakwood near Detroit.

## INDUSTRIAL NOTES.

The firm of Barber-Greene Co., of Aurora, Ill., manufacturers of car unloaders, wagon loaders, etc., has been formed by H. H. Barber, formerly sales engineer, and W. R. Greene, formerly advertising manager of the Stephenson-Adamson Manufacturing Co., Aurora, Ill.

The Republic Structural Iron Works Co., Cleveland, O., to take care of increasing business, has taken over the entire plant of the Avery Stamping Co. at Fifty-third and Lakeside, covering 100,000 square feet. On this site, following extensions, alterations and rebuilding, will be installed a complete plant for fabricating and shipping bars for concrete. Facilities will be available for handling 4,000 tons of steel and more.

The Cleveland Brick & Clay Co. of Cleveland, O., has been added to the list of licensees of The Dunn Wire-Cut Lug Brick Co. of Conneaut, O., and henceforth will make wire-cut lug paving brick. The company is one of the most prominent paving brick manufacturing concerns in northern Ohio and it has a daily productive capacity of 60,000 blocks. J. L. Higley is president of the company and A. L. Hendershot is secretary.

The A. Leschen & Sons Rope Co., St. Louis, Mo., is now constructing a $100,000 administration building adjoining its large wire rope plant. The factory buildings of this company since 1903 have occupied a 33-acre site in the northwest section of St. Louis, while the offices have been in the down-town district. This administration building is to be 115 feet long by 75 feet wide, with three stories above a well-lighted basement. The general offices will occupy the first two floors, while the third floor will contain dining rooms, kitchen and rest rooms. In the basement will be recreation rooms and shower baths.

Buildings and Structural Monthly Issue
of

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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## INQUIRIES ABOUT THE PROPOSED NATIONAL SOCIETY OF STRUCTURAL ENGINEERS.

The editor has received a considerable number of inquiries about the proposed society of structural engineers. A pamphlet will be published soon, giving a general outline of a suggested national organization of engineers. Those who would like to receive the pamphlet are requested to write to the editor for a copy.

Suggestions as to membership qualifications, dues, functions of the society, etc., will be gladly received.

## THE GUARANTEED COST PLUS A PERCENTAGE CONTRACT.

A form of contract that enables a contractor to solicit business successfully, yet protects him from the risk of severe loss, is what may be called the "guaranteed cost plus a percentage contract." Under this form of contract both parties agree as to what will probably be the actual cost of the work, if handled efficiently, and it is further agreed that if the work is completed within the estimated cost the contractor is to receive, say 10 per cent thereon as compensation for his services. If the cost exceeds the estimate, that the excess is to be deducted from the contractor's profit. But if, in this manner, the entire profit is wiped out, the contract may or may not provide that the contractor shall stand the entire loss.

If there are few elements of serious risk in the work, then it is preferable as a rule, for the contractor to assume the entire risk, in which case the contract resolves itself into the well known lump sum contract. But where the usual risks are involved, and particularly where the labor item constitutes more than about 40 per cent of the total cost, the preferable form of percentage contract provides that, when the cost exceeds the estimate by more than 10 per cent, the contractor shall not be held liable for the excess cost. With a contract of this form to offer, a contractor is often able to secure work not otherwise obtainable. The possible loss of his 10 per cent profit is itself a sufficient incentive to make him do his best to keep down the total cost. Yet by limiting his possible loss to the 10 per cent he is freed from the assumption of the entire risk incident to the work.

In times like the present, when labor is scarce and prices lack stability, we believe that this type of contract will frequently be the best for both parties. It will enable the owner to secure the services of a responsible contractor who is willing to gamble to a limited extent, but who, as a responsible business man, is not willing to assume all risks unless the contract price is very high.

## IS AN INCREASE IN THE NUMBER OF ENGINEERING STUDENTS DESIRABLE?

The writer recently engaged in a friendly debate with another engineer on the question above given. His friend held that already the field is over-run with engineers and that self interest dictates a policy of reducing the number of engineering students. The writer held that the true field of engineering is immeasurably broader than his friend conceived it to be; that, indeed, every application of science to a problem of economic production is engineering.

It seems to the writer that many of the teachers of engineering have failed themselves to appreciate the possibilities of the application of engineering to every industry whatsoever. Once it is clearly recognized that engineering is the application of science—of systematized knowledge—there should be no engineer whose vision is so narrow as to maintain that there are now too many engineers.

Without doubt, due to their habits and their circumscribed conception of what engineering can accomplish, many engineers regard the profession as being overcrowded, when, in reality, it is only a little special field of engineering that is crowded. There may be more structural engineers seeking to design bridges, let us say, than there are bridges to design. But what of the wilderness of buildings almost barren of structural engineering?

Let engineers be taught to get out of the narrow paths that their college textbooks have led them along, and they will speedily find abundant, yes, overwhelming opportunity to apply science industrially. What engineers have lacked is not sufficient opportunity but sufficient imagination.

To an engineer who has vision and who scans the world from the eminence that his education enables him to attain, opportunity beckons with a thousand hands. Let us have many fold more engineering students, and let us coincidentally broaden their vision till they see in every walk of industrial and political life a chance to apply their engineering methods.

## THE DEBT OF ENGINEERS AND CONTRACTORS TO ADVERTISERS.

The trade and professional periodicals of Great Britain—and indeed of all Europe—are inferior to those of America. There is, in fact, not a single civil engineering paper in Great Britain that adequately covers the field. "Engineering" and "The Engineer," although called civil engineering weeklies, are primarily devoted to mechanical and marine engineering. To American civil engineers who have not given thought to the causes of the inferiority of British civil engineering periodicals, it may be illuminating to know that the practice of advertising extensively in such mediums is almost unheard of among our English cousins. Under similar conditions our American engineering periodicals would undoubtedly be quite as poor as those of Europe.

The combined financial support of advertisers and subscribers has enabled the American publishers of trade and professional periodicals to scour the country for useful information and instructive illustrations. As an incidental but important byproduct of this effort, our American engineering books far surpass in number and quality those that are published in England; for our authors find most of their data in the files of our engineering papers.

Advertising, although occasionally spoken of slightingly by some engineers, is the predominant cause both of the excellence of our technical books and periodicals. Having this important fact in mind, readers of engineering papers are coming, more and more, to the practice of mentioning the paper they read when they write to an advertiser for catalogs or information. The direct evidence that manufacturers thus receive as to the effectiveness of advertising encourages their continuance of advertising.

Advertising itself is growing more educational, more informative, and this is very helpful to all readers. Facts that would seldom be called to the attention of subscribers in any other way are presented in the advertising pages, leading to investigation that terminates in the purchase of things that yield higher industrial efficiency.

While every advertiser seeks to benefit himself through publicity, it should never be forgotten that the benefit is not one sided but mutual if the advertised product is what it is claimed to be.

The two great industrial mummies among the nations of the earth are India and China. Isn't it somewhat significant that neither of these mumified aggregations of humanity has a native word in its languages that means advertising?

## THE FIELD FOR ENGINEERS AS BUILDING CONTRACTORS.

Civil engineers have entered the public works contracting field in large numbers during the last decade. There is room for a much larger number of engineers in the building contracting field, for there are approximately four building contractors to one public works contractor.

The last census gives a total of nearly 175,000 contractors engaged on architectural and engineering works. Many of these are small building contractors, of whom a large number are engaged in house building on so small a scale that they expect to make an entire year's income from two to three houses. With the present rapid means of motor car locomotion and by the use of proper cost accounting and daily progress reports, one skilled contractor can supervise a dozen or more buildings scattered over several neighboring villages and cities, and he can do it quite as effectively as the small "two-building contractor" manages his picayune work.

The engineer who enters this sort of building contracting will usually find it profitable to associate himself with a building contractor who has risen from the ranks. But when this is done the engineer should not allow himself to be dissuaded from applying new methods of construction and of management—things that "the self-made man" is prone to regard as impracticable.

Engineers who are dissatisfied with their professional outlook and who have a taste for business will find that building contracting not only gives ample exercise to every business faculty but offers no mean field for the application of engineering science.

## IS THE COMMONEST CAUSE OF FAILURE LACK OF AMBITION?

Four men who had attained celebrity in widely different walks of life—a life insurance president, an actor, a reformer and a band leader—were asked to name the commonest cause of failure. Each is said to have replied: "Lack of ambition." If this is a correct diagnosis, the most desirable quality in a teacher is the ability to inspire ambition. Probably it is nearer the truth to say that "failures" in life are due to such a complexity of causes that no one is justified in attempting to name a preponderent cause.

Many a young engineer enters upon his career with great ambition, but, little by little, finds himself weakening both in his hope and his determination to succeed in a large way. Ambition, be it remembered, grows by what it feeds upon. Small successes beget confidence and a desire to achieve larger successes. May it not be that an "o'er vaulting ambition" defeats more young men? Too great self-confidence and excessive eagerness to "arrive" are apt to be fatal to an immature and sensitive man, who sees in his early failure to advance rapidly a seeming evidence of his own incapacity.

Ambition must be tempered by patience and a will that does not flag. Ambition must be fired by strong emotion, yet steered by judgment. There is, in fact, a complex of faculties involved in the production of the successful man, and the aim of a broad educational plan should be a balanced training of the faculties—a training so complete that when the student has finished his formal education, his habits are so thoroughly formed that they will almost automatically force him to succeed.

Too little attention, we believe, has been given by most educators to the sort of training that implants all the habits essential to effective mental activity. Among the habits essential to great success are: (1) The habit of prolonged concentration of attention upon a single subject. (2) The habit of reading about successful men, with a view to increasing ambition. (3) The habit of searching for and securing all the available data applicable to a given problem. (4) The habit of solving all economic problems by the aid of quantitative data, as opposed to the habit of sophistically attempting to solve such problems by the mere use of phrases and terms not reducible to quantities. (5) The habit of seeking to combine old elements into new complexes—inventing. (6) The habit of interrogating nature for new data—research.

No, we can not safely affirm that lack of ambition is the commonest cause of failure. Success, as the engineer would put it, is a resultant of many forces, only one of which is ambition. Some of the others are concentration, persistence thoroughness, inventiveness, inquisitiveness, and quantitativeness—if we may coin a word to denote the faculty of reasoning quantitatively. Engineers, as a rule, are fairly well trained in quantitativeness, which accounts largely for their success in lines of work involving the analysis of costs. But many engineers have not been so trained as to develop in high degree both thoroughness and persistence.

If half the mental man is made by his ancestors and half by his environment, as some psychologists have it, the educational training forms so large a part of his environment that it merits even more careful consideration than it has hitherto received.

## THE DESIGN OF STEEL STACKS.

To the Editor:—Referring to an article by Mr. W. A. Hitchcock, Instructor in Engineering Mathematics in the University of Colorado, published in your issue of Oct. 25th, the results as given seem very misleading.

The loads and working stresses are those usually used in structural design, except the unit compression stress, 16,000 lb. per square inch. However, since the unit tension stress is limited to 16,000 lb. per square inch, and this is on the net section at a circumferential splice, the maximum compression is not more than about 11,000 lb. per square inch (this being based on an efficiency of 69 per cent), which is quite reasonable.

The equations given under the heading "Minimum Thickness of Plates" are evolved from those usually used in the design of stacks, the equations being simplified by the elimination of all unknowns but two, by neglecting some and expressing others accurately or approximately in terms of the remaining two. The errors introduced by these approximations are relatively small and the result as given in the curves is in a very convenient form for use. However, since the diameter of the stack is not always constant the value of S′ which the author gives as

$$S' = 0.053\,\frac{PH^2}{D} \qquad (4)$$

is more conveniently expressed

$$S' = 106\,\frac{M}{D^2} \qquad (4a)$$

In which S′ = Minimum stress in pounds per lineal inch along circumference.

M = Overturning moment in ft. lbs.

D = Diameter of stack in feet at the section being considered.

The value of S′ as given in equation (4a) clearly demonstrates that the stress per lineal inch along the circumference of the stack varies inversely as the square of the diameter and not inversely as the diameter, as would appear from a casual glance at equation (4), that the form given by the author in equation (4) invites this wrong conclusion is made evident by the fact that he himself has twice fallen into error, viz., in equations (41) and (44) when deriving formulae for the size of anchor bolts and the riveting in the anchor angle.

Under the heading of "Minimum Size of Foundation" the author discusses the subject and evolves his equations by what he apparently considers two methods. The first of these methods is theoretically sound and except for the approximations which he mentions, the results are correct. In his second solution he falls into serious error. The first solution rightly assumes that for the minimum size of foundation the resultant pressure on the foundation is at the leeward edge of the kern or $\frac{D}{8}$ from the center. Since the structure is in equilibrium the center of gravity of the supporting upward pressure of the soil is this same distance, D/8, from the center and is on a straight line, at right angles to the direction of the wind, i. e., the structure would be in equilibrium if supported on this line. Clearly then, to calculate the maximum resisting moment of the foundation, moments must be taken about an axis D/8 from the center, and expressed as a fraction, this resisting moment equals $W_t \times \frac{D}{8}$. But the author continuing after equation (18) says, "Taking moments about an axis tangent to the leeward side of the foundation, and neglecting the resisting moment due to $W_2$ and $W_1$ as small compared with Equation (17), the resisting moment is $M = W_t \times D/2$." This is decidedly at variance with the result just derived from the first solution, and clearly indicates the first error in this second solution.

The next sentence regarding a "safety factor" is hardly reasonable enough to invite comment. The author is, apparently, endeavoring to make the result for the second solution correspond to the first solution and introduces this ludicrous statement to cover the error already mentioned. His conclusion after equation (22) that a "safety factor" of approximately 2¼ gives identical results with the first solutions, has not even the justification of arithmetical accuracy. To obtain the same result as the first solution a "safety factor" of 4 must be introduced, which is what one would expect since the moment of resistance is calculated in this second solution on a moment arm D/2 instead of D/8. The second solution then is not a different solution from the first but rather the same one incorrectly applied.

In both the first and second solutions under the heading "Minimum Size of Anchor Bolts" the author has fallen into error similar to that referred to above in the second solution for minimum size of foundation, i. e., he has calculated the Moment of Resistance about the wrong axis. In the first solution the Moment of Resistance is taken about the center of the stack, which could be correct only if the total pressure on the foundation, which balances the pull of the anchors, were concentrated on a line at right angles to the wind pressure passing through the axis of the pipe. In the second solution the moment is taken about the leeward edge of the pipe, which assumes the pressure on the foundation, due to overturning, concentrated at a point on the edge of the pipe. Clearly these assumptions are both wrong. What would be reasonable to expect would be that each bolt pull is balanced by a pressure the center of which is an equal distance on the other side of the center line of the bolt circle. Then the Moment of Resistance of the anchors is $t\Sigma X^2$, where X is twice the distance of the bolt from the center line in feet and t is the stress on a bolt for which x = one foot. For the case considered in equation (24), i. e., 12 bolts in the circle.

$$M = t\Sigma X^2 = t\left[\left(2\frac{B}{2}\sin 30^\circ\right)^2 \times 2 + \left(2\frac{B}{2}\sin 60^\circ\right)^2 \times 2 + 2B^2\right] = 3B^2t$$

but $M = \frac{1}{2}PDH^2$ . . . . (25) and $t = \frac{M}{\Sigma X^2}$

$$\therefore t = \frac{M}{\Sigma X^2} = \frac{PDH^2}{6B^2} \qquad (26a)$$

The stress in bolt 3, which is the maximum stress in the group of bolts, is t × B and is therefore equal to

$$\frac{PDH^2}{6B} \text{ . . . . . . . . } (27a).$$

If unit stress in a bolt = f lb. per sq. in.

$$0.7854 \times f \times b^2 = \frac{PDH^2}{6B} \text{ . . . . . . . . } (28a)$$

Solving for b

$$b = .46\,H(PD/fB)^{1/2} \text{ . . . . . . . . } (29a)$$

Equation (29) was incorrectly derived from (28) in the original. Correctly calculated from (28) it should have read $b = .652\,H\,(PD/fB)^{1/2}$.

For the general case of n (number of) bolts.

$$\Sigma X^2 = \frac{nB^2}{4}.$$

$$\text{Stress in outermost bolt} = t \times B = \frac{M}{X^2}B = \frac{2PDH^2}{nB}.$$

Then equating actual to allowable stresses as before

$$0.7854 \times f \times b^2 = \frac{2PDH^2}{nB}.$$

from which

$$b = 1.595H(PD/nfB)^{1/2} \text{ . . . . . . . . } (31a)$$

If the third solution had been correctly applied the same equation as (31a) would have been derived as follows:

$$S' = .053\frac{PH^2}{D} \text{ . . . . } (4) \qquad S' = .106\frac{M}{D^2} \text{ . . . . } (4a)$$

Here S′ is maximum stress per lineal inch on circumference of pipe. The author's statement, that the stress in the outermost anchor = S′P is true only when S′ is the stress per lineal inch on anchor bolt circle.

From (4a) we have for the general case (where B is not equal to D)

$$\text{Stress in outermost anchor} = .106\frac{M}{B^2} \times p,$$

or equating allowable to actual stress;

$$0.7854 \times f \times b^2 = .106\frac{M}{B^2} \times p.$$

$$\text{Now } M = \frac{PDH^2}{2} \quad \text{and } p = \frac{12\pi B}{n}.$$

$$\text{Substituting we have } b = 1.595\,H\left(\frac{PD}{Bnf}\right)^{1/2} \text{ . . . . } (41a)$$

which is the same result as obtained in equation (31a) above.

The author states that the assumptions made in his solutions (1) and (3) give the same results if D = B. There are two reasons why this does not follow from the original article, viz., (a) through the error in equation (41), due to the form of equation (4) and referred to above, neither "B" nor "D" occurs in the results obtained from solution (3), i. e., in equations (41), (42) or (43); and (b), the coefficient in equation (31) obtained from solution (1), is different from the one in equation (41), solution (3). However, as we have shown solutions resembling (1) and (3), do, when based on correct assumptions, accurately applied, give the same results for all cases.

Continuing from (31a) or (41a) we get the value of b.

Using f = 15,000 and P = 20

$$b = 1.595\,H\left(\frac{20\,D}{15{,}000nB}\right)^{1/2}$$

$$= .0582\,H\left(\frac{D}{nB}\right)^{1/2}$$

The author's conclusion that his results from solutions (1) and (3) were too high and results from solution (2) were too low is quite true even though the evidence for this conclusion does not appear in his article.

With regard to riveting, the author has apparently overlooked a very important point, viz., that the joints should be designed primarily to develop the stress S′ per lineal inch. The author's contention that his recommended rivet spacing and joints will give ample strength in any section will not hold true in critical cases.

In equation (44) the author retains the error of equation (41) due, as we have stated, to the form of equation (4). Correctly derived from equation (4) or (4a) this equation should read

$$S' = .053 \frac{PH^2D}{B^2} \text{ or } = .106 \frac{M}{B_1^2} \text{ . . . . . . . . (44a)}$$

in which $B_1$ is the diameter of the shall where is connects to the base plate.

In concluding it seems that beyond expressing the results of equations (9), (10) and (15) in curves the author has presented nothing new—except the unusual conclusions due to the above mentioned errors.

H. M. White.

Designing Office, Dominion Bridge Co., Ltd., Montreal, Canada. Nov. 1, 1916.

## CLAMPING SPLICES IN REINFORCING BARS.

To the Editor: I have read with interest Mr. McCullough's letter in your Sept. 27 issue and Mr. Carl A. Herrick's answer, published in your Oct. 25 number, discussing Mr. Lasier's paper on "Clamping Splices in Reinforcing Bars."

It seems very strange to me that this subject should have been taken up by such an experienced society as the American Society of Testing Materials, which numbers among its members some of the most practical concrete engineers of the very highest authority, for I believe they are all thoroughly familiar with Bulletin No. 71, "Test of Bond," published by the University of Illinois, and compiled by D. A. Abrams under the supervision of Prof. Arthur M. Talbot.

This bulletin shows conclusively that there is absolutely no need whatever for mechanical splicing of reinforcing bars. On a test recently made by Prof. Talbot for the writer, ordinary deformed $\frac{1}{2}$-in. round bars, embedded in a concrete block only 8 in. developed the full elastic limit of the steel, and gave an average ultimate bond of about 1,200 to 1,300 lb. per square inch.

As we would only use about 200 or 250 lb. per square inch bond in actual design, it will readily be seen that the ordinary deformed bar will fully take care of all bond stresses under ordinary conditions with an extremely large factor of safety. This high bond factor of deformed bars is well established and well known, and it seems such a waste of time under these circumstances to hunt around for some mechanical means of splicing, which is of no value whatever.

There is another disadvantage in using clamped splices in that the rods are made to lie so close together that the concrete cannot flow all around them, in this way losing 25 per cent of the natural bond surface of each bar. This feature alone is enough to condemn any mechanical splicing. It also was noticed in Mr. Lasier's experiment that the clamps had a tendency to split the concrete. I think Mr. McCullough is entirely right in his statements that the idea of mechanical splicing is not only of no value but has really dangerous features.

Every good engineer is trying to reduce the cost of construction and not increase it, which brings up the query—why pay for mechanical splicing when you get better bond without it?

In conclusion, I should like to say that the entire test of the matter will come when the salesman of mechanical clips tries to sell them to a wide awake, up-to-date concrete engineer or contractor. He will then find out that this entire subject is one of "blue sky," and I can only wonder what arguments a salesman for these clips would use in order to convince a good engineer that they are of any value.

W. A. Collings.

Kansas City, Mo., Oct. 27, 1916.

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To the Editor: I should like to add my voice to that of Mr. Ernest McCullough, in your issue of Sept. 27, in a note of warning against confidence in clip splices in reinforcing bars.

Mr. McCullough points out that in a paper on this subject by E. L. Lasier, read before the American Society for Testing Materials, the author states, "That clamped lapped splices embedded in large masses of concrete undoubtedly can safely withstand a unit load equal to the unit stress in steel reinforcement." This, I claim, means nothing and is misleading. A "large mass" of concrete will stand the tension of a rod if the rod were cut in two, provided the concrete is not cracked; and a rod spliced and embedded in a large mass of concrete needs scarcely any splice to show up well in a test, if the tensile strength of the concrete is totally ignored. The latter is very frequently done in tests made for advertising purposes.

The thing of importance to designers and owners is whether or not a lop-sided splice embedded in a thin slab or shell of concrete is safe. If the shell of a tank is reinforced with rods and spliced thus the rods must not stretch out any more under their safe load at splices than in the continuous rod, or else the tank will leak, to say nothing of its safety. If it requires a large mass of concrete to make a clip splice effective such splices can be of only very limited use. They should not be used in a tank.

Analysis would condemn a short lapped splice with its eccentric stresses and high bending moment, just as analysis condemns tests made where there are large blocks of concrete around the splice. Of course this concrete will help to make the splice effective though there may not be full embedment for anchorage of the bar apart from the clamps.

The tests described by Mr. Carl A. Herrick in your issue of Oct. 25 have the bars embedded in blocks 10 in. square. This block has 400 times the cross section of the $\frac{1}{2}$-in. bars and 100 times that of the 1-in. bars. If the concrete block took, say half of the pull, it would be subject to only 263 lb. per sq. in. in the worst test at slip. A 1:2:1 concrete could stand more than this. Mr. Herrick's tests show lower load at first slip for the 1-in. bars than for the smaller bars, showing that the mass of concrete had a better chance to help out the smaller bars because of its greater relative mass.

He says nothing about whether or when the concrete cracked. This is of utmost importance.

His yield points appear to be higher than the actual yield point of this grade of steel, which seems to indicate that the actual yield point of the steel was not observed but rather the comparatively large yield of the splice.

The writer would rather trust to ample lap of rods than to any kind of splice that can be devised except turnbuckles on threaded ends.

Edward Godfrey.

Pittsburgh, Pa., Nov. 4, 1916.

## "STRENGTH OF CLAMPED SPLICES IN CONCRETE REINFORCEMENT BARS."

To the Editor: I thank you for the opportunity given me to reply to the letter written by Mr. Herrick [see Oct. 25 issue of Engineering & Contracting.—Editor] about the clips for reinforcing bars. It is noticeable that in his report of the tests he does not mention the amount of the slip stated to be "minimum point" of slip. Since, however, the point of slip, or stretch, is very close indeed to the final load it must have been at least one-tenth or one-eighth of an inch. This is the amount stated by Dr. Lasier in his tests to be the "first observed slip."

The best information we have on this subject is in

Bulletin No. 71, Engineering Experiment Station, University of Illinois, Urbana, Ill., entitled "Tests of Bond Between Concrete and Steel," by Duff A. Abrams. On page 28 it says, "There is no measurable slip of bar until a bond stress of about 260 lb. per sq. in. has been developed." On page 42 it says, "When a slip of 0.1 in. is reached, approximate equality of bond stress for all lengths of embedment is again found at about 235 lb. per sq. in."

The following statements appear on page 29: "Slipping begins at about 60 per cent of the maximum bond resistance. When the bar has slipped 0.001 in. at any point the bond stress there is about 70 per cent of the maximum bond resistance. When the slip at any point reaches 0.005 in. the bond stress there is 95 per cent of the maximum. The maximum bond resistance occurs at a slip of about 0.01 in., and the bond resistance decreases with further movement of the bar. When the bar has slipped twice the amount which was measured at the maximum bond resistance and bond stress has decreased only 10 per cent. When the bar has moved 0.05 in., five times the slip at the maximum bond resistance, the bond stress is still about 70 per cent of the maximum."

Fig. 23 on page 70 of the bulletin referred to shows results apparently about as good as any so far published of bars with clamped splices. The concrete is a 1:2:4 and the concrete used in the tests with clamped splices is far richer. The slip of one-tenth of an inch is at the point of complete failure, or very near to it. A movement of one-hundredth of an inch indicates that movement has started and from that point the bar is slipping. In his letter Mr. Herrick says the effect of tipping on the block was apparent. This of course bent the bar around the point of application of the clamps and helped them dig in, after the bars had started to move.

All the published tests of clamped splices are on deformed bars. Those for the Yale Bowl were Havemeyer bars. The others were on twisted bars. Dr. Lasier spoke of some tests in which the twists were in the same direction and other tests in which the twists were opposite in direction in the bars clamped together, thus getting as much benefit as possible from the interlocking of the twists. I have seen some tests made with smooth bars and they were so unsatisfactory that the results have never been published. In face of this, however, the company referred to in my first letter is showing pictures in advertisements of smooth bars held by clamps.

In all the tests made there were two bars clamped together in blocks of concrete and the pull was applied to both. The concrete blocks tilted as the pull tended to straighten the steel. This gave the clamps an opportunity to dig in and get the best possible effect. To determine fully the value of the clamps similar bars embedded in the same quality of concrete should have been tested at the same time. The effect of the tensile value of the concrete would have been surprising to a man who has never made such a test. This method of testing, however, is not proper. The block of concrete should be so large that no tilting can occur. If this is not done then the block should be placed on the bed of a machine and but one rod should be pulled. At the time the tests are made in this manner identical bars in identical blocks of concrete of identical mixtures should be tested without the clamps. That is, the endeavor should be to obtain a straight pull of one bar past another, one set having clamps and the other set having no clamps. The tests should cover all types of deformed and twisted bars and also plain rounds and squares. The tests, however, so far published do not convince me that clamps should be used. Not one test with which I am familiar has been properly made in order that a proper comparison could be made with the behavior of bars without clamps. Therefore I repeat that it is dangerous to advertise that clamps are good for splicing reinforcing.

Yours truly,

Ernest McCullough.

Chicago, Ill.

## BAD EFFECTS RESULTING FROM THE USE OF SALT WATER IN REINFORCED CONCRETE STRUCTURES BUILT IN TROPICAL COUNTRIES.

Contributed by J. L. Harrison, Acting Supervising Engineer, Bureau of Public Works, Manila, P. I.

About four years ago the writer's attention was attracted by a number of large cracks near the bottoms of the girders of one of the spans of a concrete slab and girder bridge in the town of Marilao, Bulacan Province, P. I. The nature of these cracks made it seem unlikely that they were due to any overload on this span and indeed, had there been any doubt as to the adequacy of the original design (which there was not) five other spans in the same structure, all in good condition, would have been ample evidence that no question of ordinary overload was involved. After some speculation as to the probable cause of these cracks it was decided to cut into the concrete for the purpose of determining its hardness and to ascertain the condition of the steel. The concrete was accordingly removed until the reinforcing bars were exposed when it was found that these bars were covered with a layer of about ⅛ in. of rust. As iron rust occupies about 2½ times the space which is occupied by the iron or steel from which it is formed, this layer of scale evidently represented the addition of something over ⅛ in. to the sectional dimensions of the reinforcing bars in this span. Therefore, as the increase in section that had been caused by the addition of about ⅛ in. to the sectional dimensions of the bars in this span was, undoubtedly, enough to split open the concrete in these girders, it seemed evident that the cracks in this span must have been caused by this rust. Moreover as there was a pronounced crack just above the main reinforcing steel in each girder (Fig. 1) and most of the girders also showed one or more cracks on the bottom (Fig. 2) the position of the cracks themselves was such as to confirm the conclusion that they had been caused by the rusting of the reinforcing bars.

The discovery of so unusual a cause for the cracking which had taken place in this span, while all of the other spans in this bridge appeared to be in good condition, led to an investigation as to a possible reason for the rusting that had caused the cracking. Absolutely nothing unusual was found except that river water was used in mixing the concrete for this bridge, which is located so near to the sea that the water under it is salty during the dry season while as soon as the rains begin the greater volume of off flow keeps it practically fresh. It was learned that the first span of this structure was built just before the rains began so that salt water had probably been used in mixing the concrete which went into it. Chemical analysis later checked this conclusion. In the next four spans the water used was practically fresh. Brackish water was again used in the last span. However, as it is a common practice in the United States to use salt for the purpose of reducing the freezing point of concrete which is to be placed during cold weather, the fact that salt water had been used in mixing the concrete for this span (though in violation of the standard specifications of the Bureau of Public Works) did not at once impress any one as an adequate cause for the serious rusting of this steel.

Not long after this a small culvert in Bulacan Province failed because of overload and when the site was cleared for a new structure it was observed that many of the reinforcing bars in it were more or less rusted. No cause for this could be assigned, and, as the culvert was only about 6 years old, the presence of so much rust caused considerable alarm among the engineers to whose attention the matter was brought as it tended to discredit reinforced concrete as a proper form of construction for this country. Moreover, a number of other structures in other parts of the Islands were known to be showing signs of trouble. Therefore, as the United States Bureau of Standards (Technologic Paper No. 18) had declared that where electrolysis is to be feared it is dangerous to use salt, it was decided to gather samples of concrete from the structures where rusting steel was known to exist and, though no electrolysis due to stray currents was involved in any of these structures to ask the Philippine Bureau of Science for a determination of the chlorine content of each sample. Table I shows the result of the examinations made. From this table it will be observed that the analyses of the samples submitted all show some chlorine. Analyses have been asked for only where doubt existed as to whether fresh water had been used. Where it is known that salt water was used, no analyses have been made.

The results of these analyses, coupled with the fact that a number of structures in which salt water was known to have been used were showing unmistakable signs of rusting steel made it seem at least possible that the salt in the water used for gaging was at the basis of the trouble. This presumption is, of course, largely a negative one, but the fact that every structure where trouble has so far been found, and these structures now number well over twenty, has been gaged with salt water makes the presumption seem a logical one.

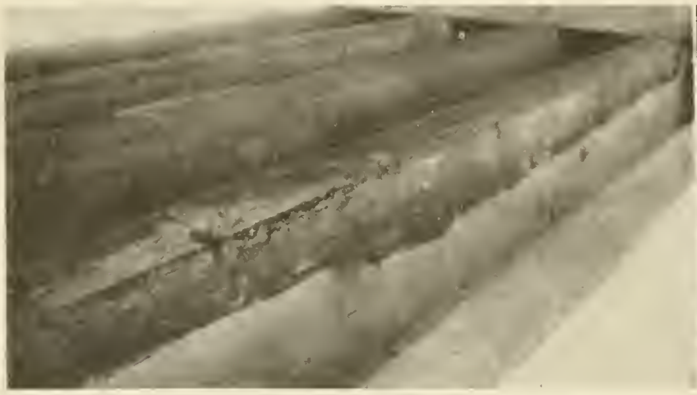

Fig. 1—Girders, Marilao Bridge, Showing Cracks Over Main Reinforcing Steel.

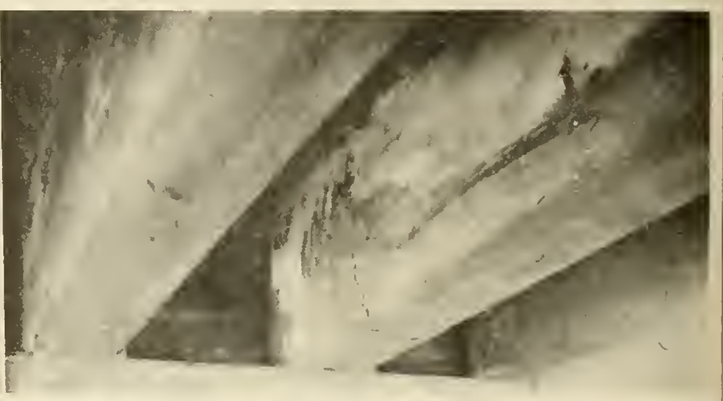

Fig. 2—Girders, Marilao Bridge, Showing Cracks in Bottoms of the Girders, also Cracks Along a Stirrup.

It should be noted that the percentages given are for the chlorine content of the concrete. In commenting on the sample of concrete taken from the Constabulary Headquarters Building, Iloilo (Bureau of Science Lab. No. 121923) the analyst says: "Salt (Na. Cl) in water, assuming 12.5 lb. used in mixing per cubic foot of concrete, (assuming that sp. gr. is 2.58), ——— 1.44 per cent." The chlorine content in this case was 0.07 per cent.

It is, of course, impossible to tell exactly how much water was used in mixing the concrete from which the samples were taken, for some engineers use a fairly dry mixture while others use a great deal of water. However, the assumptions made by the analyst seem to be fair for the average of the work done in this country. For the purpose of arriving at a general idea of how much salt there was in the water used in mixing the various concrete analyzed it may, therefore, be assumed that the percentage of salt in the water was about 20 times as high as the percentage of salt which is now found by an analysis of a sample of the concrete.

It is interesting to note that none of these samples show as much salt as it is customary to use in the United States to hinder the freezing of concrete placed during cold weather. In the United States the immunity from disasterous results is undoubtedly due to the comparatively low temperature which prevails during most of the year, a temperature so low that chemical action is greatly hindered if not entirely stopped. The constant high temperature of the tropics, together with the higher humidity prevailing here, greatly aids chemical action with the result that more serious trouble with rusting steel, apparently caused by the use of salt water, has already been encountered in the Philippine Islands, than has been encountered in the United States though many concrete structures there are two or three times as old as the oldest concrete structures in this country.

In order to check the assumption that salt is the direct cause of the rapid rusting of such reinforcing bars as have been found in bad condition, a few samples of rust have also been sent to the Bureau of Science for determination. Table I shows the amount of chlorine found in three samples from three different structures. Coupled with the fact that among the thousands of concrete structures erected by the Bureau of Public Works during the past 10 years, no rusting steel has been found except in structures where salt water is known to have been used or where an analysis of the concrete has shown a noticeable percentage of salt, the fact that the rust from these three structures also shows a marked chlorine content would seem to constitute a strong case against the chlorine salts and would suggest the exclusion of salty or even brackish water from all concrete which is to be used in reinforced structures. This is more important where structures must endure the trying climate of the tropics but is likely to prove important even in temperate climates.

Some engineers may reason that one-tenth of 1 per cent of chlorine is too small to be of importance as an indication of the effect of the use of salt water. However, one-tenth of 1 per cent of chlorine is equivalent to slightly more than one-tenth of 1 per cent of hydrochloric acid and while this chlorine does not represent the presence of free hydrochloric acid, it is entirely probable that any ferric chloride which is formed by the first rusting of the reinforcing steel in the presence of the salt which has been incorporated in the concrete, is very soon oxidized with the liberation of the chlorine to again attack the steel.

The exact nature of the chemical reactions is a matter concerning which there is undoubtedly room for much

TABLE I.—CHLORINE FOUND IN FIVE SAMPLES OF CONCRETE.

| Structure. | Built. | Chlorine in concrete. | Remarks. |
|---|---|---|---|
| Marilao Bridge, Bulacan. . . . . . . . | 1909 | 0.08 | Steel covered with about 1/8 in. of rust. Concrete porous. |
| Culvert 27.10, Manila, North Road | 1906 | 0.16 | Rusting general. Bad scale on three or four bars. Concrete hard, but very porous. |
| Pantal Bridge, Pangasinan. . . . . . | . . . | 0.28 | Rusting slight. Concrete good. |
| Jail, Iloilo . . . . . . . . . . . . . . . . . . . . . . | 1911 | 0.25 | Steel in many parts of building rusting badly. Scales over 1/8 in. thick found. Sand used too fine. Concrete porous. |
| Constabulary Headquarters, Iloilo | 1913 | 0.07 | Steel rusting badly. Concrete sound but porous. Sand too fine. |

Besides the above, which are typical, a number of structures in which salt water is known to have been used, are showing the same indications of the rusting of the reinforcing steel that have been noted in the above-mentioned structures.

TABLE II.—CHLORINE FOUND IN THREE SAMPLES OF RUST.

| Structure. | Built. | Water used. | Chlorine. Pct. | Remarks. |
|---|---|---|---|---|
| Marilao Bridge. . . . . . . | 1909 | Brackish | 0.07 | Rust scales about 1/8 in. thick. |
| Jail, Iloilo . . . . . . . . . . . | 1911 | Salty | 0.23 | Rust scales over 1/8 in. thick. |
| Constabulary Baraks | 1913 | Brackish | 0.10 | Rust scales over 1/16 in. thick. |

discussion, but having present air, moisture, iron and even a trace of salt there can be no doubt that the conditions are ideal for the creation of a cycle of chemical action which will result in the progressive breakdown of the iron in the form of a chloride, its immediate oxidation to common ferric oxide, and the consequent liberation of the chlorine, in some active form, to again attack the iron. Such a chemical cycle is always progressive and can not be stopped as long as there is a supply of iron or steel to be attacked, air and moisture sufficient to complete the oxidation of the chloride, and a temperature at which chemical reactions will take place. Viewed in this light, the presence of one-tenth of 1 per cent of chlorine becomes not only a matter of primary importance, but, in fact, a complete explanation of the existence of the heavy scales of rust which have been found on the reinforcing bars in a numbers of structures which have been examined.

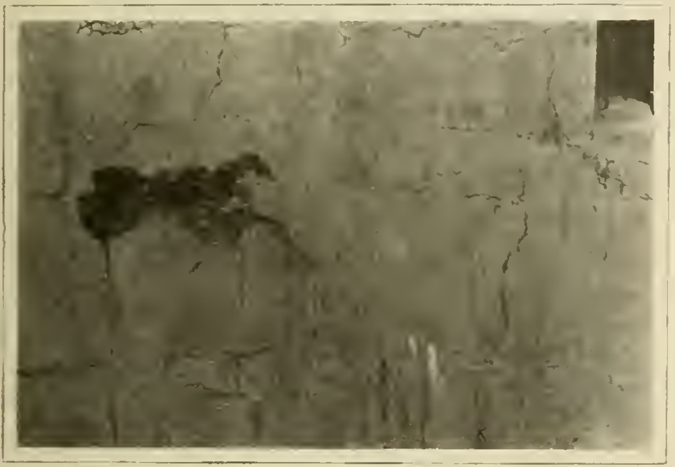

Fig. 3—Wall at Iloilo Provincial Jail.

While, from these facts, it seems evident that the use of salt water in reinforced structures will often prove disastrous there remains the question as to how often unfortunate results are likely to be met with. That the immediate failure of a structure in which salt water has been used is by no means certain is beyond dispute. About a year ago the writer inspected three concrete bridegs in which salt water is known to have been used. All are apparently in perfect condition. They are now about 6 years old. There is nothing unusual about these structures unless it be that the concrete in them is uncommonly hard and dense. The District Engineer who built them showed them to the writer as positive proof that sea water can be used in reinforced structures with impunity.

On the other hand the writer knows of a bridge where the contractor, in direct violation of the specifications under which he was working and contrary to the express instructions of the inspector, used sea water in mixing his concrete. Within a year the steel in this bridge was so badly rusted and the concrete so badly cracked that the structure was considered valueless, and condemned as unsafe. The concrete in this case was porous and below normal in strength.

These are the extremes. What the average life of a structure in which salt water has been used may be, will begin to appear when signs of trouble are found on such structures as the three bridges above referred to.

There is one city in the Philippine Islands where salt water has been used in a large proportion of the reinforced concrete work. Here, within a radius of about a mile the writer has examined upwards of a dozen concrete structures, both public and private, and so far has found only one structure over 5 years old where there is no evidence of rusting steel, and that is the only structure he has found where only fresh water and aggregates from fresh water were used. In one of the private buildings, a structure about 3 years old, the interior columns are in such bad condition that the owner is under the necessity of rebuilding them and the beams seem to be in almost as bad condition. The concrete in these structures has, practically without exception, been made from a good grade of beach or river gravel and a fine sand sometimes taken from the beach and sometimes taken from one of the two rivers near this city but almost never from above the reach of salt water. This sand is far too fine for good concrete work and the concrete in which it has been used is noticeably porous. There is an electric light system in this city which may have had some effect in hastening the destruction of the reinforcing steel in these structures. Still these structures are, on the whole, a good indication of the short life of reinforcing steel that is burried in concrete containing salt, and as many of these structures now show cause for the belief that they will be unsafe before they have had as long a life as would be normal for a frame building, the seriousness of the situation may be readily seen.

From the fact that in dense concrete, although gaged with salt water, reinforcing bars have been preserved for some time without showing any tendency to rust while, when buried in porous concrete, disastrous results have often followed with surprising rapidity, it would seem that the porosity of the concrete must be a factor in the process of deterioration. For example it is no doubt true that in an absolutely dry atmosphere steel could be packed in salt without being materially damaged thereby, and by deduction it would seem fair to assume that in very dense concrete, where the steel is not only supposed to be largely protected from contact with moisture but where even if some moisture reaches it, it is also protected by the alkaline qualities of the cement, it might last indefinitely in spite of the presence of chlorine salts, but that if the porosity of the concrete is such as to permit moisture and air to penetrate easily, the protective influence of the alkalinity of the concrete might very probably be overcome by the salt and rapid rusting result.

This theory probably explains the reason for the rapid destruction of steel buried in porous concrete. The only apparent difficulty with this theory is to be noted in the behavior of bars in the interior walls of a building. Because the interior of a building is always drier than the exterior one would expect to find less evidence of rusting steel here than in exterior walls. However, this is not the case, for when the steel in a building begins to rust, evidences of rusting can be fully as often found within the building as on the outside. This is probably not really in violation of the theory proposed but undoubtedly indicates that there must either be enough moisture present in the concrete to permit the salt to overcome the protecting influence of the alkalinity of the concrete but that porosity increases the rapidity of the rusting by increasing the accessibility of the supply of oxygen or that, owing to the high humidity which prevails in the Philippine Islands, high porosity facilitates the absorption of the necessary moisture from the vapor in the air. This deduction is tentative but seems to fit the facts better than an

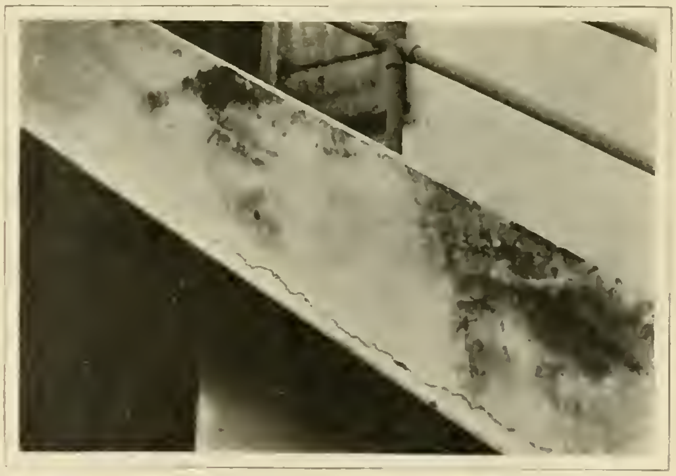

Fig. 4—Crack in Stair Girder at Constabulary Headquarters Building, Iloilo.

assumption that porosity aids rusting by permitting moisture to penetrate to the reinforcing steel in its liquid form.

From these and many similar facts, the conclusion has been reached that salt water should be excluded from all reinforced concrete work undertaken in tropical or semitropical countries. The amount by which the rusting of reinforcing steel is accelerated by the use of salt water in the concrete in which it is imbedded has not yet been determined but the fact that a considerable proportion of the structures in which salt water has been used show signs of the rapid rusting of the reinforcing steel before they are five years old seems to be a sufficient reason for urging that much more caution ought to be exercised in regard to the use of salty or brackish water. In fact the writer believes that in tropical and semitropical regions, especially where the humidity is high, the use of salt water in mixing concrete for reinforced structures should be absolutely prohibited in all specifications and the prohibition should be rigidly enforced. In cooler climates physical deterioration due to chemical action is slower than it is in tropical climates and as both humidity and precipitation are lower, the bad effects to be expected from the use of salt will appear much more slowly. Still, even here as it is entirely probable that the life of any reinforced structure will be governed by the life of the reinforcing steel used in it, it is foolish to run the risk of hastening the deterioration of the steel by incorporating quantities of this destructive agent in the concrete in which it is embedded.

## A COLLAPSED CONCRETE-BLOCK BUILDING.

The accompanying illustration shows a concrete-block store building which collapsed at Lovell, Wyo., a short while ago. The building had a very insufficient foundation the immediate cause of the failure was the excavation of a trench adjacent to the building for the foundation of a new structure. The trench was only 1 ft. in width and 1½ ft. deep, extending more than the length of the building. This trench was completed during the afternoon and the collapse took place about 6 o'clock in the evening. Soils in the arid region contain very little humus and are usually very fine grained, being extremely fluxible when wet. In this instance, the ground water table was within 5 ft. of the surface and the capillary power of the soil was sufficient to keep the soil moist to the surface.

Collapsed Concrete-Block Building at Lovell, Wyo.

Fifteen states now have Boards of Health with engineering divisions who have legal authority or otherwise to exercise control over the disposal of sewerage and operation of sewage treatment works.

It is estimated that the net return to the city of New York for each inspector employed on water waste detection is about $7.75 per day.

## TEST OF A GROINED ARCH.*

The test of any such idea as here proposed may be divided into two parts, that made by applying known methods of design to several cases of this type of structure, which may be termed a more or less theoretical test, and by the construction of an actual model and testing it to failure. Inasmuch as small models are apt to give results which materially differ from the actual conditions met with in practical construction, the writer has attempted in this test to construct a model of sufficient dimensions to warrant its being recognized as representative. A model which has a clear span of 7 ft. and is placed on columns 4 ft. long ought to be considered as giving these representative conditions, yet is not without the bounds of reason when considered as an experiment. These were the dimensions adopted for the model constructed.

In order to obviate all arch action in the load, and also to allow for extensometer readings on the upper surface, the method of loading used in this test was essentially as follows: Half pigs of iron, as usually found ready for the cupola at foundries, run a little less than 24 in. in length and of such width that three laid side by side will occupy slightly less than 24 in. Therefore, by laying out 24-in. squares over the surface of the floor, and planning for extensometer readings along the dividing lines of these squares, the iron may be piled in crisscrossed layers averaging three pigs to the layer, thus making each pile self-supporting and still leaving room for extensometer readings between the piles.

A small test pit about 2 ft. deep was made where it had been decided to build the model. The foundation was found to be of coarse gravel, which has a fairly high bearing capacity, at least three tons per square foot. Under a load of four times the designed load, the bearing at the foot of each column was approximately this amount.

The next step was to design the forms. The main arch form was built in four sections which were bolted together along the groin lines, nailed securely at the corners, and finally strips of 2 by 3 spruce were fastened to all four sides and securely bolted at their intersections. All of this was done in order that the arch form should be self-supporting, being, in fact, an arch itself with the thrust counteracted by securely fastening the four sections together. This form rested directly on the tops of the column forms.

It is interesting to note in the design of the column forms the manner in which the corner joints were lapped in order that the stress on the nails in every case should be shear rather than straight tension. In this way any tendency towards springing the joints was avoided, and the use of clamps made unnecessary. The forms were made up in the carpenter shop of the Massachusetts Institute of Technology, and transported by truck to Waltham.

The erection of the forms required only one hour's time for the writer, with the aid of a laborer. First, two 3 by 4 spruce joists were laid across each pit for the columns, then the column forms were placed, resting on the joist by the long middle battens. After the column forms were placed and leveled, one of the sections of the arch was placed on top of the column forms and its pointed end held up in place temporarily by a light stick; the next section was similarly placed and then three bolts inserted along the intersection. This process was continued until all four sections were in place; the corners were then securely nailed, and, finally, the pieces of 2 by 3 spruce were run around the outside and securely bolted at the corners.

Although some excess cost was entailed by the careful construction of the forms, it was more than made up for by the ease in erection and stripping, and also by the excellent condition of the forms after removal. With very little repairing the forms could easily be used eight or ten times, showing that although the original cost of arch forms may be slightly greater than those for flat slabs, the better construction necessitated more than pays for itself in the time saved in the erection and removal.

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*From a paper, "The Groined Arch as a Means of Concrete Floor Construction," in the October Journal of the Boston Society of Civil Engineers. The author of the paper, Mr. H. Whittemore Brown is Assistant, Testing Materials Laboratories, Massachusetts Institute of Technology.

The labor necessary in placing the steel was of course very small. As specified in the design, $\frac{3}{4}$-in. plain round, mild steel bars were used. Tension and bending tests showed material to be about up to the standard, although not what would be termed first class. Eight rods 20 ft. long were ordered; these were bent on the job. Wooden blocks were wired to the bars where it was desired to take extensometer readings. In placing the steel, care was taken to see that the rods were accurately placed, especially through the crown of the arch and the upper portion of the columns.

The concrete work involved numerous difficulties because of the lack of both time and space. Fairly representative tests, however, were made of the sand and cement with the result shown by Table 1, which shows the materials to be of good average strength.

Test of the cement with hydrochloric acid showed no signs of dirt or other foreign matter.

This shows a well-graded sand with a minimum of fine material. Washing the sand revealed no objectionable foreign matter.

In proportioning the mixture to be used, there was little to be considered, inasmuch as it was not the concrete that was being tested, but rather its action in the arch, so that a 1:2:4 mixture was chosen rather arbitrarily as being of common proportions. Gravel passing a $\frac{3}{4}$-in. and held on a $\frac{1}{4}$-in. screen was used. Each batch was made fairly dry, so that in placing the concrete in the arch, the joint between batches could be made nearly perpendicular to the surface of the forms, thus making the joint more efficient in carrying the stress. About an hour after the pouring had been completed, holes were made in the upper surface of the floor by pressing a steel rod into the slightly hardened concrete, thus allowing for the insertion of steel plugs for the extensometers. About 24 hours after the pouring, the whole floor was covered with hay and thoroughly soaked, in order that the drying out should not be too rapid. The forms were removed at the end of three weeks.

Extensometer inserts consisting of pieces of $\frac{5}{8}$-in. steel rods about an inch long were placed in the holes made in the concrete with a mixture of cement and plaster of Paris. After the concrete had been poured it was thought advisable to attempt to make strain gage readings on the concrete in the columns. Plugs were here stuck on the columns with a mixture of cement and plaster of Paris; some of these proved satisfactory and gave readings which checked up closely with the design, while others failed to adhere at all.

In order that the strain gage reading should be of some value, it was necessary to determine the modulus of elasticity of the actual concrete used in the model at the age of testing. For determining the modulus, blocks 8 by 8 by 24 in. were made of the actual concrete used; $\frac{3}{4}$-in. rods were placed 20 in. apart in each block, and held in place by projecting into the sides of the form. As comment on this method of placing the extensometer inserts, it may be said that difficulty was encountered because of the shrinkage of the concrete, which tended to crack the block through the plane of the rods. Since that time I have had opportunity to make other modulus tests on plain blocks, the inserts being made by boring 1-in. holes with a diamond drill, and setting the steel plugs with neat cement and plaster of Paris.

TABLE I. CEMENT AND SAND TESTS.

24-hour Neat—
(1) 340.
(2) 390. Av. = 365 lb. per sq. in.
7-day Neat—
(1) 610.
(2) 585. Av. = 597.5 lb. per sq. in.
Standard Mortar—
(1) 280.
(2) 300. Av. = 287 lb. per. sq. in.
(3) 280.
Waltham Mortar—
(1) 270.
(2) 295. Av. = 262 lb. per sq. in.
(3) 270. = 91.5% of Standard.
35-day Neat—
(1) 695.
(2) 725. Av 710 lb. per sq. in
Standard—
(1) 290.
(2) 295. Av. = 295 lb. per sq. in.
(3) 300.
Waltham—
(1) 290.
(2) 280. Av. = 285 lb. per sq. in.
(3) 285. = 96.5% of Standard.

RESULTS OF SCREENING TEST OF SAND.

| | |
|---|---|
| Left on No. 10 | 18.4% |
| No. 20 | 39.1% |
| No. 30 | 26.0% |
| No. 50 | 12.8% |
| Through No. 50 | 3.0% |

In order to measure the deflection of the arch it was necessary to design some form of apparatus which should combine the three following elements: First, it should not be elaborate or expensive, because it is likely to be ruined with the failure of the arch; second, it should be easily readable from the exterior of the arch, so as not to endanger the observer upon a sudden failure of the arch; and, third, it should be fairly accurate, at least to 0.01 in.

It was decided to make the apparatus of wood, mounting a lever with arms as 1 to 50 on a board back, having the fulcrum simply a snug fit about the supporting screw, but having the point of application on the short arm fixed by a steel point fitting into a prick-punch hole, also in steel. The apparatus was made easily in a few hours by the writer in the Institute carpenter shop.

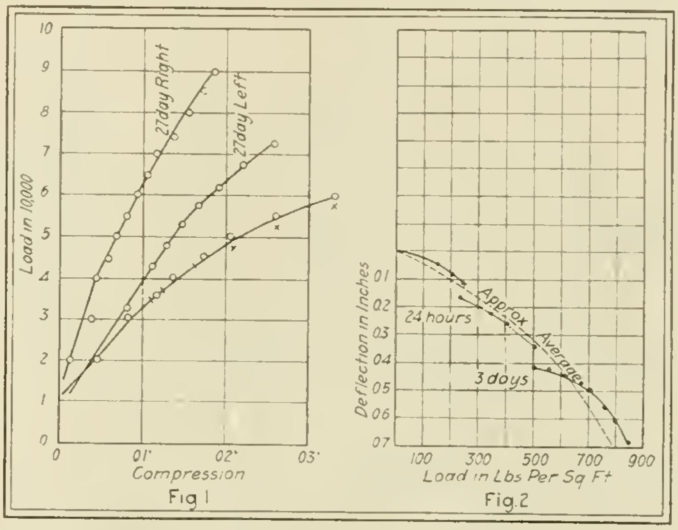

Fig. 1—Modulus Tests, Load Compression Curves.
Fig. 2—Deflection of Arch.

After construction, it was necessary to calibrate the apparatus. This was accomplished by placing it in a small Riehle testing machine, where the deflection could be controlled easily. The actual deflection was measured with a micrometer, and compared with the scale reading on the apparatus, the scale being made with divisions 50 times the actual deflection and placed at a radius distance of 50 in. from the fulcrum. An error averaging about 7 per cent was found. The radius distance of the scale was then increased $3\frac{1}{2}$ in., and the readings then were found to be accurate within a few thousandths of an inch. A new scale was then constructed, giving a wider range of deflection, and then tested. In this it was found that the effect of curvature became apparent in the larger deflections.

Here it occurred to the writer that the effect of curvature might be overcome by the use of a scale made of cross-section paper, and reading from a fixed point on the pointer.

Tests of 6-in. by 6-in. cylinders which had been made as the mixing progressed were made at 7, 14 and 28 days; a strength of 2,070 lb. per sq. in. being obtained in 28 days.

Modulus tests were made at 21 and 28 days, the results of which were platted in Fig. I. The average of the 28-day tests used in the checking of the design was 1,178,000 lb. per sq. in.

Before commencing the loading of the test floor it was necessary to mark off the squares for the piles of pig iron, so that the loading might be carried on expeditiously without interfering with the extensometer inserts. The inserts were then punched and bored for a gage length of 20 in., a 20-in. Berry strain gage being used.

In order that there should be a minimum amount of lifting in connection with the handling of the iron, a one-horse cart was procured, so that it was only necessary to load the iron into the cart from the pile, weigh the load, and then back the cart up to the floor, which was purposely made of convenient height for this operation. In this manner it was possible to carry on the loading quite rapidly. Loads were applied in increments of 1,600 lb., equivalent to 25 lb. per sq. ft., until the designed load was reached, and after that in increments of 3,200 lb. until a load of 54,400 lb. had been applied, equivalent to 850 lb. per sq. ft.

Extensometer readings were taken after adding each increment of load. Dust and dirt made it difficult always to be sure that the holes for the point of the extensometer were clear, which might account for the sudden variations in some of the readings.

After a load of 150 lb. per sq. ft. was reached, the readings on the interior of the arch had to be abandoned on account of the increasing height of the piles of iron.

Deflection readings were also taken with each increment of loading. (Fig. 2.) After a load had been applied and before another was ready, some slight settlement occurred, usually not over .003 or .004 in. Twenty-four hours elapsed before load 250 and 300, and during this time a settlement of 0.06 in. occurred. The total deflection immediately after the application of the 500 load was 0.342 in. Three days elapsed between load 500 and 550, during which time a deflection of 0.069 in. occurred, showing that the deflection becomes practically constant after 24 hours. The total deflection upon the application of the 850 lb. load was 0.675 in. The deflection apparatus rested directly on the ground; thus the deflection readings included not only deflection of the arch but also the settlement of the whole structure on its foundations.

When a load of 750 lb. per sq. ft. was reached, cracks were noticed on the under side of the concrete at the crown and on the outside of the columns about a foot from their tops. The next increment of loading opened these cracks and produced another set running diagonally across corners of the top of the arch about 2 ft. from the columns. Explanation of this would seem to be that the steel had reached its yield point, thus allowing the center of the arch to fall slightly, causing cracks at the lower side at the center, on the upper side near the ends and on the outside of the columns where the tension caused by their bending was excessive.

When the steel rods were placed in the crown one set was wrapped with paper, two sets were thoroughly greased and the fourth set left untreated, but no difference in action was visible between any of them, showing that the bond between the steel and the concrete was broken without causing any undue destruction of the concrete.

The load remained on the arch for about one month without showing any signs of increase in the cracks already visible, although the deflection was not determined. At the end of that time about half of the corner piles were thrown upon the center of the arch without any appreciable change. In unloading, one-half of the arch was unloaded first; leaving the other half under its full load, again without any signs of failure. Then the half of the load remaining lying nearer the edge was removed, leaving a load of approximately six tons on the middle quarter of the floor and again without any signs of failure on the part of the arch.

When it was desired to tear down the arch it was only necessary to take a sledge hammer and knock away the concrete from around the rods at the crown, cut the rods there with a hack saw, then a few blows of the sledge hammer separated the arch into four sections, which were easily removed.

## ELEVATOR PITS AND MACHINERY FLOORS IN CONCRETE BUILDINGS.

Contributed by Albert M. Wolf,* Assoc. M. Am. Soc. C. E.

The literature on the design and construction of elevator pits and machinery floors is so meagre that the writer feels that the following notes may be of value to structural designers.

### Elevator Pits.

For the type of elevators generally used in factories and warehouses of reinforced concrete, the depth of pit required below the lowest floor served, is governed not so much by the buffer requirements, as by the type of door used. Ordinarily a depth of 3 ft. 6 in. is sufficient for the proper installation of buffers, but if the Meeker type or Peelle counterbalanced doors are used at openings, the pit must have sufficient depth to allow the lower half of the door to travel into the pit. The depth usually required, is from 6 in. to 1 ft. more than half the height of the door opening at the lower landing depending on the make of door used, the Peelle type requiring more than the Meeker. Since elevator doors are generally made 7 ft. or 8 ft. high the depth of pits necessary will vary from 4 ft. to 5 ft. The elevator contractor and the door manufacturer should of course be consulted before designing pits for special elevators or those involving the use of unusual doors.

Since in most factories and warehouses the elevators run to the basement, the bottom of the pits will be below the sewer and drain lines. This means that special attention must be given to the waterproofing of the same. or ejector pumps provided to pump out the seepage collecting in the pits. If the pit is to be made waterproof all column or wall footings adjoining the elevator shaft must be carried down so that the portions under the pit are at least 6 in. and preferably 1 ft. below finished floor line of the pit. This will allow the construction of the pit floor as a monolithic slab with reinforcing extending both the length and width of the same, bent up into the side walls near outer face (see Fig. 1) to act as cantilever reinforcement therefor. A key should be formed in the top of slab directly under the walls and the same poured as soon after the base as possible so as to obtain a watertight joint. A rich and very dense concrete (with an integral waterproofing compound or hydrate of lime added if the work is to resist any considerable head of water) should be used in elevator pit construction, and the same be very thoroughly tamped and spaded to insure slabs free from voids and stone pockets. To aid in preventing the formation of shrinkage cracks in top of walls at least two ½ in. diameter bars should be placed near the top bent to lap at corners with bars in walls at right angle to one in question.

Except for the smallest size pits, it is poor economy to use less than 12-in. walls and floors owing to the difficulty of waterproofing thinner slabs. The sidewalls of the pit are supported at the bottom by the pit floor and at the ends by the walls at right angles. This means that they can be reinforced as either cantilever walls to resist the earth pressure (Fig. 1) or when the pits are very deep, the top portion of the side wall for a width of a foot or so can be reinforced as a beam between the walls at right angles to it and the slab between this and the pit floor reinforced as a vertical slab. The bottom of pit should be reinforced between sidewalls as a slab resisting the upward pressure of water (if the pit is under hydrostatic pressure) and these bars can be bent up into the sidewalls to act either as cantilever reinforcement (Fig. 1) or for vertical slab reinforcement on the inside of slab between bottom and the assumed beam at the top (Fig. 2).

Sometimes the tops of side walls are anchored to the adjacent floor slab in lieu of reinforcing the top portion as a beam, but this action is rather uncertain and any settlement of floor or pit will cause unsightly cracks in the floor. The best practice seems to indicate the pit walls should be built up to the level of the top of the floor slab and the latter separated from the pit walls by an expansion joint filled with asphaltic cement, thus allowing the floor to be placed at any convenient time after the pit is completed.

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*Principal Assistant Engineer, Condron Co., Structural Engineers, Chicago.

### Elevator Machinery Floors.

The machines for operating elevators are in general placed on supports spanning the shaft at some distance (usually 3 to 4 ft.) above the roof line of the building. In the great majority of cases structural beams are used as supports for the elevator machine and a plank floor laid on them to furnish a platform for workmen inspecting or repairing the machinery. Sometimes the plank floor is omitted and a protective screen of wire mesh placed below the beams.

In fireproof buildings of reinforced concrete it would seem more logical to construct the elevator machinery floors of a fire resisting material such as concrete, or structural steel encased in concrete, and thus avoid the danger of the elevator machines being dropped into the basement by a small fire starting in or about the penthouse while the remainder of the structure might be unharmed.

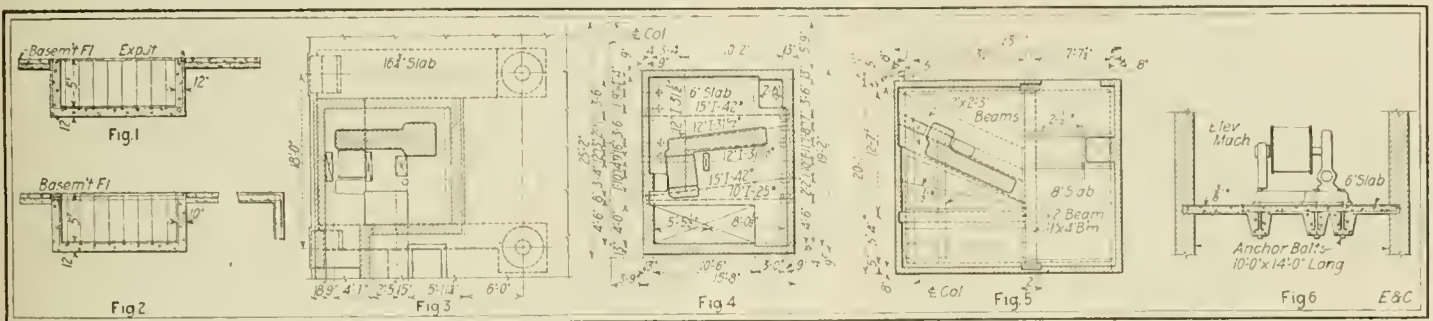


Fig. 1—Elevator Pit Sidewalls Reinforced as Cantilever Walls. Fig. 2—Elevator Pit with Sidewalls Reinforced as Vertical Slabs. Fig. 3—Concrete Elevator Machinery Floor, Built as Part of Main Roof. An Economical Construction Possible Only Where Upper Story is High. Fig. 4—Elevator Machinery Floor of Steel Beams Covered With Concrete Slab. Fig. 5—Reinforced Concrete Beams and Slab for Elevator Machinery Floor. Fig. 6—Typical Layout for Structural Steel and Concrete Elevator Machinery Support.

Just which type of floor will prove the most economical for any given case depends upon the size, speed and capacity of elevator, the arrangement of the machinery and time of placing the floor with respect to completion of the remainder of the building.

For comparatively small elevators in buildings with high story heights which will allow placing the elevator machinery floor at the same level as the roof, reinforced concrete may be used to good advantage, unless the arrangement of holes in the floor is such as to make the main support members very narrow and deep. An elevator machinery floor of this type is shown in Fig. 3. The roof construction is of the flat slab type (two way reinforced) with the portion of the slab supporting the elevator machinery and the penthouse walls deepened sufficiently to make up the resisting moment required to support the additional loads imposed. The slab being built as a monolithic portion of the main roof, considerable advantage is gained due to continuous beam action, which is not the case when the machinery floor is raised some distance above the roof, thus making all beams and slabs simply supported.

For complicated machinery layouts requiring skewed setting of beams similar to that shown in Fig. 4, reinforced concrete is not economically adapted since the loads are usually concentrated at points where the floor is pierced with various openings making the economic design of concrete beams to carry the loads, impossible. The larger the elevator and the higher the speed at which it operates, the greater the loads (and hence impact) to be carried by the machinery floor and also the difficulties attendant with the design of concrete beam and slab floors. Where there is only a width of a few inches between openings with heavy concentrations on the slab nearby, structural steel beams present practically the only satisfactory solution of the problem of design of main supports of the elevator machine, for very narrow and deep concrete beams are impractical, and they also materially cut down the head room or necessitate a raise in the level of the floor if used. Compare depth of floor construction shown in Fig. 5, a concrete floor, with that in Fig. 6. Then, also, if elevator service is desired as soon as possible after the floors of the building have been completed, the machines should rest on supports which can be placed and used immediately. Concrete beams must cure and harden for a few weeks before being subjected to suddenly applied loads producing much impact, and, therefore, where speedy completion of the elevator plant is required reinforced concrete is out of the question, at least for the main members of the floor.

Structural steel beams can be quickly set in place, the elevator machine blocked up on them, and the reinforced concrete floor slab and the encasement of the beams poured at any time thereafter in forms suspended directly from the steel beams without other support, except for very long spans between beams. Herein lies one point of economy over the floor with reinforced concrete beams, which when poured must be supported from below by costly centering and formwork spanning the elevator shaft. Of course this economy will not always be apparent in the bids on a large job, for this item is a very small percentage of the total cost of the building. Nevertheless, the writer has found by careful comparative estimates made on machinery floors with layouts of machines and openings giving the reinforced concrete floor its most favorable arrangement, that a concrete floor on structural steel I-beams or channels would cost the same or even less, to say nothing of the advantages gained in speed of erection, saving in headroom in the elevator shaft and ease of erecting the elevator machinery on steel beams before placing the floor as compared with placing it afterward as is the case where reinforced concrete supports and floors are used.

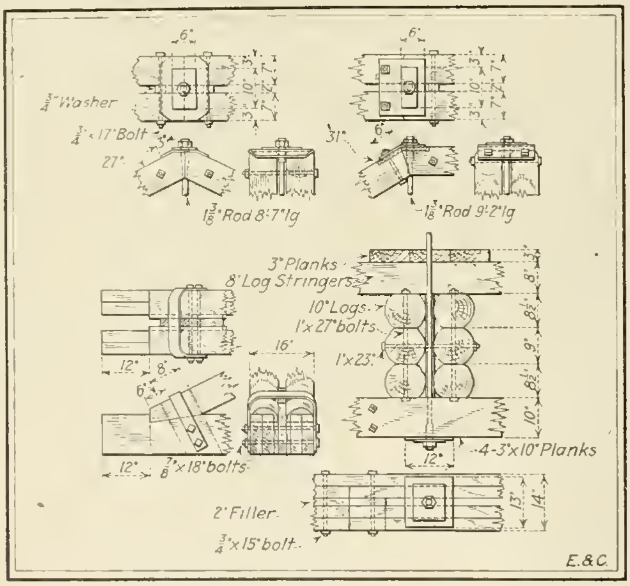
A typical elevator machinery floor detail is shown in Fig. 6. The main supporting beams consist of pairs of channels set back to back with space enough between to allow placing the anchor bolts for the machine with washers on the underside. This allows very accurate setting and leveling of the machine and a more convenient layout of openings in the floor for cables, counterweight guides, etc., because of the relatively small width taken up by the structural beams as compared with those of concrete. When setting up the machine, it is blocked so that the concrete slab should be reinforced transversely between the supporting beams and the side walls on a corbel or better still a 6 or 8 in. bearing on the penthouse walls. On account of the heavy concentrations and the fact that the slab will tend to act as a continuous beam over the steel beams, it is essential that reinforcing bars as required by moment, $M = \frac{WL}{12}$ should be placed in top of slab at such points. The slabs should be designed to carry not the elevator machinery, the load from which goes directly to the steel beams on account of their location directly under the same, but a live load of from 150 lb. to 200 lb. per square foot of surrounding floor, depending upon the weight of machine parts which may be handled thereon. Owing to the fact that the loading may be non-uniform, and concentrated, it is well to provide reinforcement in bottom of slab to resist a moment, $M = \frac{WL}{8}$.

For this same reason the slab should be made somewhat thicker than actually required for the most economical percentage of steel. It should be remembered that in special structures of this type it does not pay to save a few pounds of steel or cubic feet of concrete by making assumptions which do not provide for unusual, but plausible conditions of loading. At least 0.3 per cent of distributing steel should be placed in the bottom of the slab parallel to the beams.

The steel beams should be designed to carry the loads indicated on the elevator manufacturer's layout, doubled to provide for impact, and the proper proportion of the dead and live load of slab, with bearing plates at ends to distribute the load over a portion of the penthouse walls. Before encasing the beams they should be wrapped with a wire mesh or netting to give a bond for the fireproofing. The top of beams if placed at a level 1 in. above bottom of the floor slab furnish a support for the lower slab bars.

## SPECIAL DESIGN OF LOG TRUSS BRIDGE.

Log truss bridges of special design have been constructed in Uinta County, Utah, by the State Road Commission, of which E. R. Morgan is engineer. These bridges were erected in localities where concrete and steel were extraordinarily expensive on account of the remoteness from the railroad and where stone and logs could be obtained locally. A special design was prepared so that the logs could be handled in the round and so the iron parts could be forged locally instead of having to be cast and shipped to the site, as is necessary for the standard wood truss bridge. The bridges are erected on stone abutments. Details of the joints for these special log truss bridges are shown in the accompanying sketch. The iron parts required include the following:



Details of Log Truss Bridge.

BILL OF IRON FOR ONE LOG QUEEN-TRUSS.

4—1⅜" rods, 9' 2" long, with 6" upset and threaded.
8—Hexagonal nuts for same.
4—½" bent plate washers (see sketch).
4—½"x4"x10" plate washers (see sketch).
4—½"x12"x13" plate washers (see sketch).
4—½"x8"x9" plate washers (see sketch).
[illegible]—½"x3" strap iron stirrups (see sketch).
4—¾"x17" bolts (with washers).
8—¾"x8½" bolts (one washer sq.).
8—⅞"x18" bolts (no washers).
16—1"x27" bolts (with washers).
8—1"x23" bolts (with washers).
24—¾"x15" bolts (with washers).
4—¾" C. I. washers, 2" thick.

BILL OF IRON FOR ONE LOG KING-TRUSS.

2—1⅜" rods, 8' 7" long, with 6" upset and threaded.
4—Hexagonal nuts for same.
2—½" bent plate washers (see sketch).
2—½"x6"x10" plate washers (see sketch).
2—½"x12"x13" plate washers (see sketch).
2—½"x8"x9" plate washers (see sketch).
4—½"x3" strap iron stirrups (see sketch).
4—¾"x17" bolts (with washers).
8—⅞"x18" bolts (no washers).
8—1"x27" bolts (with washers).

## COMPARATIVE COSTS FOR CONCRETE AND TIMBER FACTORY BUILDINGS.

The National Lumber Manufacturers' Association early in September issued as a technical letter a paper prepared by F. E. Davidson, architect and engineer, Chicago, Ill. In his paper Mr. Davidson discusses the economics of concrete and timber factory building and gives comparative costs of the two types in a specific case. Mr. Davidson's paper is given below and following it is a statement by Mr. T. L. Condron.

### Economics of Concrete and Timber Factory Buildings.

By F. E. Davidson.

I have as architect designed and superintended the construction of a great many manufacturing plants, both of fireproof construction and of the type known as standard mill, and based upon the actual construction costs the increased cost of a strictly fireproof manufacturing building is from 25 to 35 per cent greater than the actual first cost of an exactly similar standard mill building. In considering these costs I have included everything absolutely necessary to complete the building ready for the owner's occupancy; that is, the heating, lighting, elevators, power wiring, lighting fixtures, sprinkler equipment, window shades, window screens, etc., are all included in the cost of both types of construction. It is, of course, manifest that the actual cost of many of the items of construction will be practically identical for either type of building. I have designed standard mill factory buildings in Chicago that have cost, complete, including all of these various items, less than 7 ct. a cubic foot, but I have never been able to secure the construction of a fireproof building including all of these items of cost for less than 11 ct. a cubic foot, nor do I know of any accurate data showing any lower costs than those noted above.

**Depreciation.**—When depreciation charges are considered I have always recommended that a depreciation charge of 3½ per cent per year be charged against a standard mill building, and that a depreciation charge of 2½ per cent per year be charged against an absolutely fireproof building. This, of course, shows a slight advantage in favor of fireproof construction, considering depreciation only.

**Maintenance Charges.**—As to maintenance charges: It is of course evident that as much outside painting, and in fact as much interior painting and calcimining or whitewashing, will be required for a fireproof building as for a building of standard mill construction. Practically the only thing which wears and must be replaced in a mill building is the finished flooring, and I do not know of any accurate records of maintenance cost of a standard mill building which will average more than three-fourths of 1 per cent per year. Yet, on the other hand, I do not known of any records of the maintenance charges on fireproof buildings which will average less than one-half of 1 per cent per year.

**Insurance Rating.**—As to insurance ratings: Every architect and engineer of course knows that a standard mill sprinklered building is given a much lower insurance rating than an absolutely fireproof building if unsprinklered. And even if the fireproof building is sprinklered the difference in the actual ratings between a standard mill sprinklered factory and a standard fireproof sprinklered factory, with the ordinary occupancy, will only amount to about 10 ct. per $1,000 per year on the insurable value of the building. These insurance figures can be verified by any one, and I do not believe that any one will dispute them.

**Advantages of Standard Mill Construction.**—Thus, considering first cost, depreciation, maintenance and insurance only, the argument is all in favor of the standard mill building, and when I refer to a standard mill building I mean a building designed by a thoroughly competent industrial architect, who will enclose all stairs and elevators with brick masonry walls and have the openings to same protected with automatic fire doors, and with all windows, with the possible exception of street frontages, of sheet metal and glazed with wired glass, and with no unprotected vertical openings between any floors in the building. These are items which, more than any others, affect insurance ratings on any building.

There are in addition to the questions above noted some additional arguments in favor of the standard mill factory building. One of the principal ones which have recently been brought to the writer's attention is the fact that a skilled artisan will not work if compelled to stand on a concrete floor, if he can secure employment at equal wages in a standard mill building. Many owners of fireproof buildings have had trouble in keeping help, due to this reason only and in some fireproof factories it has been necessary to cover the concrete floor with a layer of asphalt, or to place cork carpet or wood thereon, in order to render the factory "habitable."

There is yet another argument in favor of the standard mill building, which in any large city should be given serious consideration, and that is the salvage value of the building itself. We all know that a standard mill building can be wrecked, and if the work is carefully done all the structural material can be used in another structure, whereas in wrecking a concrete structure there is no salvage. In fact, I have been quoted by one of the largest contracting firms in Chicago a price for the wrecking of a monolithic concrete building which amounted to a trifle more than one-half of the original cost of the building, and our American cities are growing so rapidly that it would indeed be a courageous investor, or at least one blessed with a prophetic vision, who could predict as to what particular use a certain piece of property would be best adapted for twenty-five or thirty years in the future.

**A Specific Case.**—In order that the statement in regard to comparative costs made above may be brought to a definite basis, a specific case will be given in detail.

Tables I and II that follow represent the lowest proposals received by my office on a building to be erected for Walter E. Olson, of 42 South Laflin St., Chicago. Mr. Olson, whose business is rug manufacturing, decided to build an addition to his present factory and at first purposed erecting the addition of reinforced concrete.

With this idea in view plans and specifications were drawn for a concrete structure, the Condron Co., structural engineers of Chicago, doing the engineering work. After these plans were made the owner decided to find out what a standard mill building would cost him, with the result that another set of plans and specifications was prepared by Davidson & Weiss, architects, Chicago, and bids were taken on both sets of plans, which amounted to practically duplicating the contemplated concrete building in mill construction as nearly as it is possible to have uniformity of design between the two types.

The figures that follow are self-explanatory:

TABLE I.

| | |
|---|---|
| Excavation, concrete foundations and brick masonry complete | $15,884 |
| Carpenter work complete | 14,374 |
| Miscellaneous concrete, including fireproof stairs | 3,547 |
| Structural steel and miscellaneous iron | 7,150 |
| Sheet metal | 138 |
| Cut stone | 735 |
| Roofing | 145 |
| Glazing | 1,365 |
| Steel sash | 1,436 |
| Fire doors | 3,360 |
| Fire escapes | 1,479 |
| Painting | 720 |
| Plumbing | 615 |
| Electric wiring | 1,100 |
| Plastering | 90 |
| Total | $52,138 |

Exclusive of heating and sprinkler equipment.

**General Data on Building.**—The building is 55 ft. 1½ in. by 124 ft. 7½ in. in area, six stories and basement, and contains 598,477 cu. ft. The story heights are in general 13 ft. 6 in. floor to floor. The typical bays of the building are 18 ft. by 17 ft. 10 in. The structure was designed for a live load of 150 lb. per square foot in accordance with the requirements of the Chicago Building Code, which limits the stresses in long leaf Southern pine to 1,300 lb. per square inch in bending and 1,100 lb. per square inch in direct compression with the grain.

The floor girders are composed of two 10-in. by 18-in. timbers bolted together, and the floor joists or beams are 8 in. by 16 in. located 4 ft. 6 in. center to center. The girders are carried on steel post caps of the writer's own design. The floor construction is a 3-in. tongued and grooved flooring finished with a ⅞-in. maple wearing surface.

This building is an addition to an existing factory, and it was necessary to use cantilever foundations for the entire structure. This, of course, is true for either design.

The timber specified in the contract was to be of the select structural grade as per the new grading rules of the Southern Pine Association. The cost to the contractor in this particular building at the site was as follows: Approximately $34.50 per thousand for the 18-in. stock and $33 per thousand for the 16-in. stock.

**Mill Construction Cost Per Cubic Foot.**—On the basis of 598,477 cu. ft., the cost of the building complete as shown from the total cost given above, exclusive of heating, sprinkler and architects' fees, is 8¾ ct. per cubic feet. In figuring the cubical contents the space from the bottom of the footings to the top of parapet wall is included.

**Reinforced Concrete Cost Per Cubic Foot.**—For the same building proposals were taken on the monolithic flat slab concrete design and the lowest proposals presented were as follows:

TABLE II.

| | |
|---|---|
| Foundations, reinforced concrete, masonry and carpenter work | $55,941 |
| Sheet metal | 138 |
| Cut stone | 735 |
| Roofing | 145 |
| Glazing | 1,470 |
| Steel sash | 1,936 |
| Fire doors | 3,360 |
| Fire escapes | 1,479 |
| Painting | 790 |
| Plumbing | 725 |
| Electric wiring | 1,250 |
| Plastering | 90 |
| Total | $68,059 |

Exclusive of heating and sprinkler equipment.

The cubic contents of reinforced concrete design on the same basis as cubic contents for the timber design equal 585,467 cu. ft. Thus the total estimated cost of building, exclusive of heating, sprinkler and architects' fees, would be 11½ ct. per cubic foot, and the difference in first cost of the two designs, exclusive of heating, sprinkler and architects' fees, is $15,921.

**Summary.**—The concrete design was made as inexpensive as possible and provided for the use of high carbon steel reinforcing material, and in other ways costs were cut as much as possible, in spite of which fact there was a difference of 2¾ ct. per cubic foot in the cost of the two types of construction.

In this instance it will be noted that the cost of the concrete structure would have been about 30 per cent more than the cost of the mill building, and this saving to the owner was effected in addition to the advantages he gained in the matter of quick erection, etc. The insurance rate is the same on the standard mill building as it would have been on the concrete structure.

## Statement by T. L. Condron.

The "Technical Letter No. 6," issued by the National Manufacturers' Association, entitled, "Economics of Concrete and Timber Factory Buildings," by Mr. F. E. Davidson, has just been brought to the writer's attention, in which it is shown that the bids received for a particular building indicated that reinforced concrete construction would cost about 30 per cent more than "standard mill" construction. As our company is referred to as having prepared the plans for the reinforced concrete building used in this basis of comparison, we believe you will be interested in some later data from us on this very interesting subject, which shows that for a factory building for the Imperial Brass Mfg. Co. the bids received for the concrete construction ran only 17 per cent above the cost for the mill construction for the same building, or only 4 per cent more than the cost of the mill construction of the building cited by Mr. Davidson.

In all of these comparisons the cost of heating, sprinkler and elevator equipment and plumbing fixtures has been omitted, and it is obvious that if the cost of these equipments, which may be assumed at 28 ct. per square foot of floor surface for either type of building, be added to the cost per square foot shown by the bids received the percentage of additional cost of concrete over mill construction will be reduced. Making this addition in all cases the reinforced concrete construction of the Imperial Brass Co. building is shown to be 14 per cent more than for standard mill construction for the same building, or only 3 per cent more than the cost of the mill building cited by Mr. Davidson.

These comparisons are even more instructive when it is noted that the Imperial building was designed for heavier live loads per square foot than the Olson building cited by Mr. Davidson, and that the bids for the Imperial building for standard mill construction totaled 11 per cent less per square foot of floor than in the case of the Olson building, showing that our design for standard mill construction meets the requirement for an exceedingly economical structure. Our designs for the concrete construction of both the Imperial and the Olson buildings were identical so far as type and unit stresses were concerned and were for flat slab or girderless floor construction.

Table III presents all the figures on which the above comments are made in ready form for comparison.

It is perhaps well to state that in the case of the Olson building, made the basis of the comparison by Mr. Davidson (the author of "Technical Letter No. 6"), the Condron Co. was engaged as consulting engineers by Mr. Davidson, architect, to prepare the general design for the reinforced concrete construction of the proposed Olson building, and Mr. Davidson prepared the architectural plans, including the general layout for both the concrete and mill buildings.

The specifications and general instructions to bidders for both constructions were issued by Mr. Davidson and after the concrete plans were started and fairly well advanced, but before bids were called for, the architect informed us that the owner had decided to abandon the idea of a concrete building and to build of "mill construction." We suggested that since the concrete plans were so far advanced it would be interesting and perhaps instructive to get comparative bids. This was done and the results have proved interesting but we think they are not especially instructive. The column spacing was modified in making up the mill design, changing the spans from 21 ft. 0 in. (concrete design) to 17 ft. 10 in. (mill design).

At the time the bids were called for on the Olson building the plans for the Imperial Brass Co. building were underway in our office and in this case the owner desired bids on both concrete and mill construction. The Imperial building was to be an addition to a standard mill building located in the same neighborhood as the Olson building, and after the bids were received the owner decided to have the addition built of standard mill construction, notwithstanding the small difference in cost; and doubtless one of the factors in arriving at this decision was the greater ease in tearing down a mill building provided it was found desirable to change the character of the improvement within a comparatively few years.

Attention has been called to the objection of skilled artisans working upon concrete floors instead of wooden floors. As you doubtless know, many reinforced concrete buildings are provided with maple wearing surfaces to obviate this very objection, but it is worth while to remember in this connection that the Ford Motor Co., with several hundred acres of floor space devoted to factory purposes and employing many thousands of skilled artisans, has adopted concrete construction for all of its buildings, and has used on all its later buildings cement finish floors rather than wooden wearing surfaces. This is also true of practically all of the automobile factories throughout the U. S. and there seems to be a growing preference for concrete floors over wooden floors, especially in machine shops. The trouble with working on concrete floors is largely imaginary in buildings that are heated. It is true that in unheated buildings, stone and concrete, being better conductors than wood, are cold to the feet and therefore unpleasant to work on.

The equipment of buildings with sprinklers seems to the writer to be quite as important in concrete construction as in mill construction, because the contents of buildings are usually not fireproof even if the building construction itself is fire resisting and we have seen serious conflagrations spread throughout so-called fireproof buildings fed only by the inflammable contents. And in these cases the fires would have been almost insignificant had the buildings been equipped with sprinklers.

With reference to the "prophetic vision" necessary to know what kind of building will be required in any locality in the future, there is no question but what a first-class reinforced concrete building six or eight stories high with wide column spacing will serve any and all purposes for which buildings may be required so long as men carry on pursuits in structures protecting them from the weather.

The Imperial Brass Co. building that has been referred to, and which is now under construction, is 85 ft. by 125 ft. in area, 6 stories and basement, and has 74,000 sq. ft. of floor space. The cubical contents measured in the same manner as adopted for the Olson building are 972,000 cu. ft. for the standard mill construction and 993,400 cu. ft. for the reinforced concrete construction, the difference in cubical contents being due to the greater depth of foundations for the concrete construction. The typical bays of the standard mill construction are 18 ft. by 16 ft. 6 in. and for the reinforced concrete construction 18 ft. by 21 ft. 6 in. The structures were designed for a live load of 175 lb. per sq. ft. in accordance with requirements of the Chicago Building Code.

TABLE III.—COMPARISON OF COSTS OF MILL AND CONCRETE CONSTRUCTION.

Comparison of Bids for a Factory Building of "Standard Mill" and Reinforced Concrete.

| | Olson Building. | | Imperial Building. | |
|---|---|---|---|---|
| Type of construction | Mill. | Conc. | Mill. | Conc. |
| Total floor areas in sq. ft. | 44,500 | 45,000 | 74,000 | 74,000 |
| Masonry (brick, stone and concrete) | $20,250 | $56,766 | $31,097 | $80,000 |
| Ornamental and miscl. iron, etc. | 11,989 | 4,839 | 13,250 | ...... |
| Carpentry | 14,374 | ...... | 23,500 | ...... |
| Steel sash, glazing, painting, roofing, etc. | 3,894 | 4,479 | 6,069 | 6,883 |
| Plumbing (drainage) | 615 | 725 | 1,536 | 1,669 |
| Wiring | 1,100 | 1,250 | *1,830 | *2,060 |
| Total of bids received | $52,138 | $68,059 | $77,282 | $90,479 |
| Per sq. ft. of floor areas | $1.17 | $1.51 | $1.04 | $1.22 |
| Relative costs per sq. ft. | 100% | 129% | 89% | 104% |
| Relative costs per sq. ft. | ...... | ...... | 100% | 117% |
| Adding 28c per sq. ft. of floor area to cover cost of sprinkler, heating and elevator equipment and plumbing fixtures | $1.45 | $1.79 | $1.32 | $1.50 |
| Relative costs per sq. ft. | 100% | 124% | 91% | 103% |
| Relative costs per sq. ft. | ...... | ...... | 100% | 114% |
| Per cubic foot of building | 8½c | 11¼c | 8c | 9⅛c |
| Relative costs per cu. ft. | 100% | 132% | 94% | 107% |
| Relative costs per cu. ft. | ...... | ...... | 100% | 114% |
| Adding 2c per cu. ft. of building to cover cost of sprinkler, heating and elevator equipment and plumbing fixtures | 10½c | 13¼c | 10c | 11⅛c |
| Relative costs per cu. ft. | 100% | 126% | 95% | 106% |
| Relative costs per cu. ft. | ...... | ...... | 100% | 112½% |

*Estimates of wiring only.

In the standard mill construction the floor girders are composed of two 8 in. by 18 in. timbers, bolted together, and the floor joists or beams are 8 in. by 16 in., spaced 4 ft. 6 in. center to center. The girders are carried on steel post caps built up of plates and angles. The floor construction is 3-in. tongued and grooved yellow pine flooring with ⅞-in. maple wearing surface. The timber specified was select structural grade Southern Pine according to the specifications for Dense Southern Pine given in the Southern Pine Association Density Rule Book of March 15, 1916. No. 1 Douglas fir was permitted as an alternate for the above yellow pine.

The reinforced concrete design called for an 8-in. reinforced concrete slab supported by flaring column heads, and reinforced concrete round columns.

The foundations for the mill construction building are the usual spread type except that cantilever foundations are required on the side adjacent to the old building.

## DIAGRAM FOR OBTAINING NUMBER FEET B. M. IN VARIOUS TIMBERS.

Contributed by W. R. Roof.

The accompanying diagram affords a convenient method for obtaining the number of feet board measure for various sizes of timber. The operation is quite simple and hardly requires any explanation. The following example is given to show the manner in which the chart is used:

Find the number of board feet in a piece of timber 8 in. x 10 in. x 18 ft.: First, read down from top of diagram on line corresponding to 8-in. width. Second, read to right from left hand side of diagram on line corresponding to 10-in. depth. Third, from intersection of these two lines, follow curve until it intersects horizontal line corresponding to 18-ft. length. Fourth, from this intersection read downward to bottom of diagram, at which place the number of board feet is found to be 120.

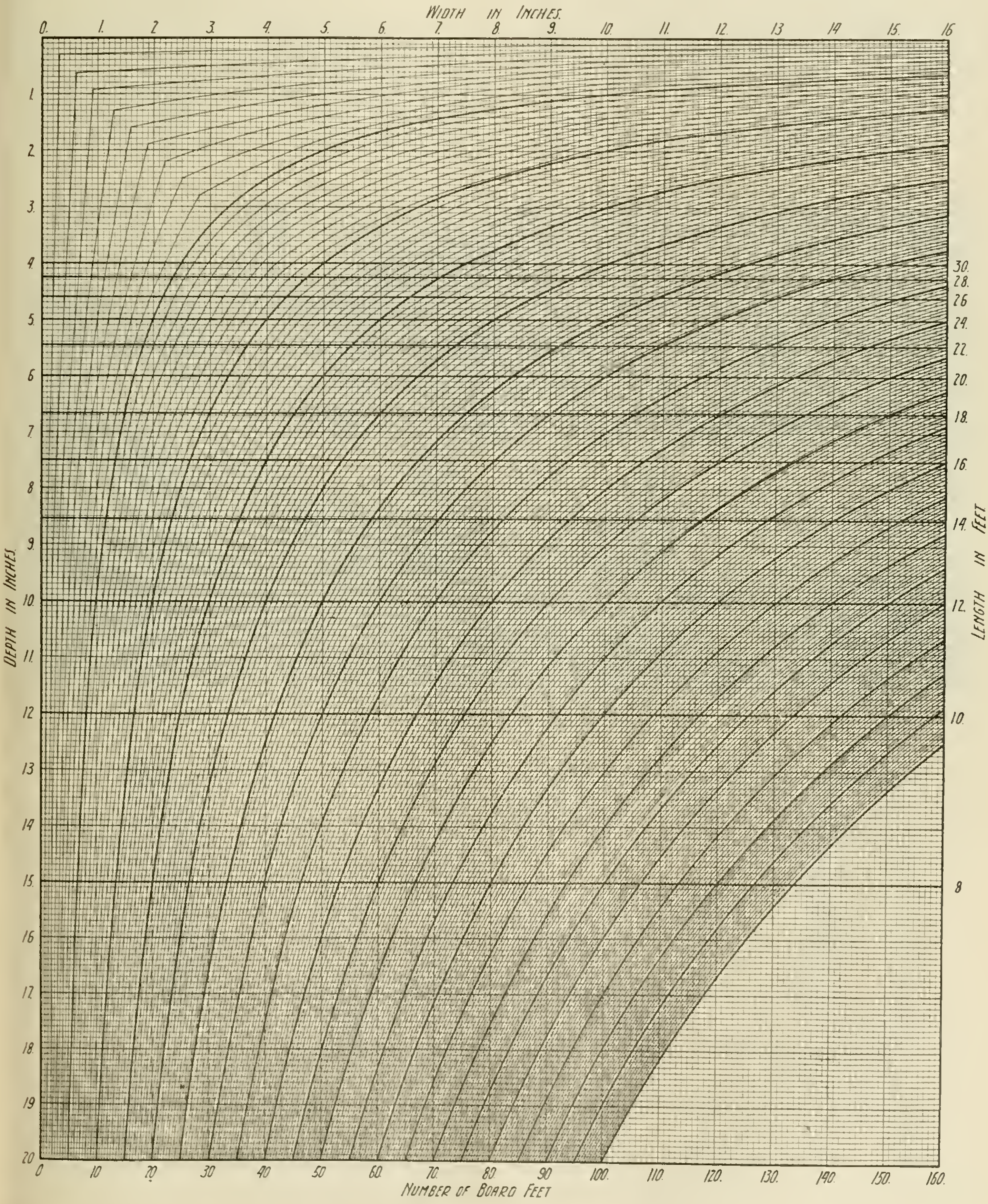
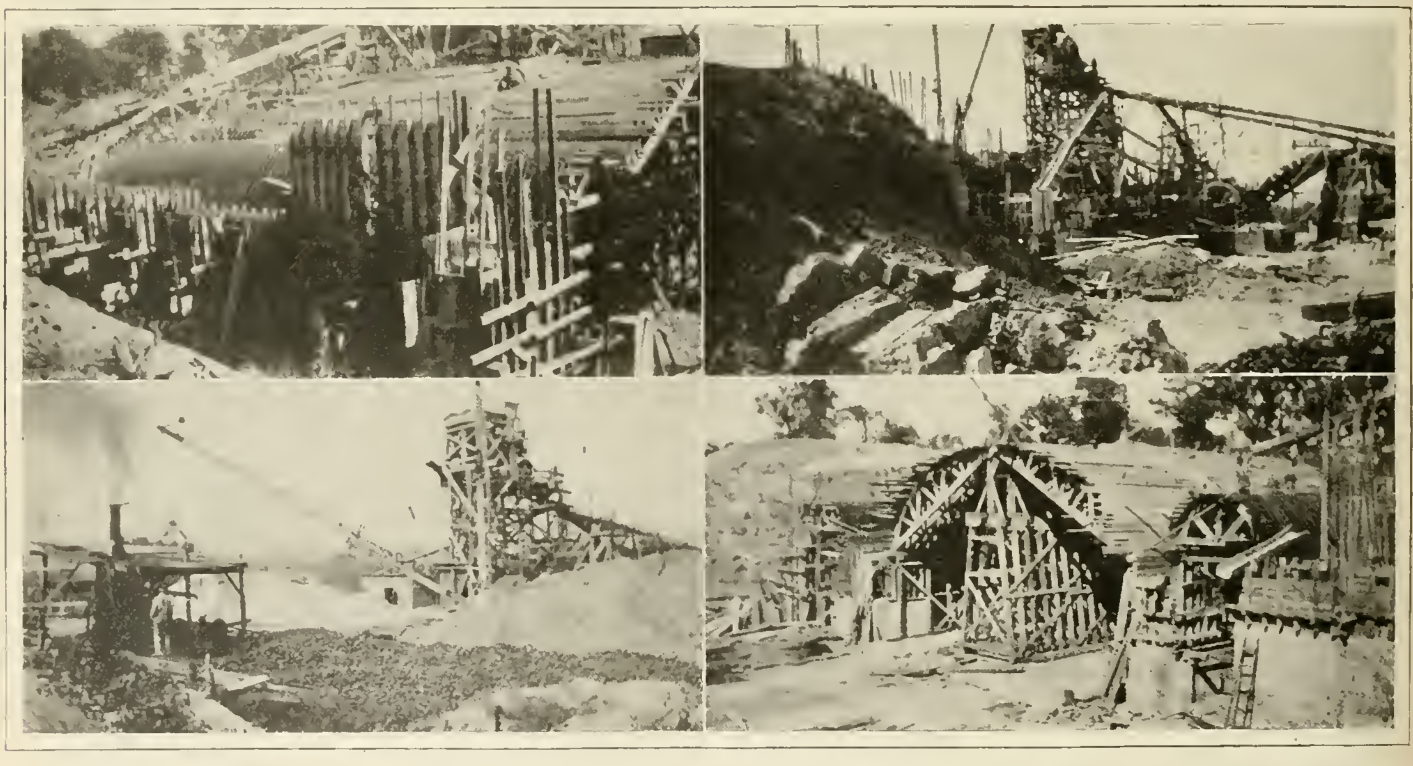


Diagram for Finding Number of Board Feet in a Piece of Timber.

## A 160-FT. WIDE BRIDGE AND SOME NOTES ON THE CONSTRUCTION PLANT.

A 160 ft. wide bridge is being constructed at Des Moines, Ia. The structure is a part of the extensive improvements which the state of Iowa is making in the district surrounding the Capitol.

The bridge is of reinforced concrete of the semi-gravity type and will be faced with Bedford blue cut stone. The width from hand rail to hand rail will be 160 ft., and the length from face to face of abutment will be 100 ft. There will be a dirt fill carrying a driveway and sidewalks, between which will be grass and shrubbery. The bridge spans a deep cut on Court Ave. It has been designed to harmonize with the local conditions, the idea being to have no breaks in the topography of the grounds across the deep cut.



Construction Views of State Bridge on Capitol Grounds, Des Moines, Iowa.

The plant used in the erection of the structure has a number of interesting features. The materials are shipped in and spotted on a spur track about 1,600 ft. from the mixing plant. The crushed stone, sand and gravel are shoveled into Lee unloaders and dumped into dump wagons. Teams are employed to haul the materials to the mixing plant after being helped up the hill by a belt-driven hoist with motor.

A clam shell is employed to pick the materials off the pile and load them into elevated hoppers. From the hoppers the stone and sand are drawn off into a measuring hopper and are then allowed to empty by gravity into the mixer drum.

The cement is loaded onto an elevator platform from the cement house and is hoisted to the mixer platform by means of a small drum on the mixer. The mixed concrete is spouted directly into the forms.

The accompanying views reproduced from photographs taken the middle of last September will give an idea of the status of the work at that time.

The bridge was designed by Mr. E. L. Masqueray, St. Paul, Minn. He also is architect for the work of improving the ground around the Capitol. The Koss Construction Co., Des Moines, Ia., has the contract for constructing the bridge. The contract price is $68,000.

## LAYING CONCRETE IN FREEZING WEATHER.

In order to have the Troy Lock completed and ready for navigation within the specified time, it was found necessary to carry on the work of placing concrete in the lock during the winter 1914-1915. A description of the various expedients used to prevent damage to the concrete from frost is given by Mr. D. A. Watts, assistant engineer, in the November-December Professional Memoirs of the U. S. Corps of Engineers.

When the temperature fell below about 50° F., the sand, gravel and water used in the concrete were heated. A steam jet placed in the water tank of the concrete mixer sufficed to heat the water. The sand and gravel were heated by steam jets located at the bottom of the bins of the mixer. The steam, escaping upward through the mass, made this method very effective, even when the mixer was running to full capacity. When running slowly, however, it was sometimes necessary to reduce the supply of steam, as it made the concrete too hot for the men to work in the forms and, in confined forms, resulted in so much vapor that the men could not see properly.

This method was also used on the construction of the dam, when toward the end of the working season the temperature fell below moderate. As the river water was shortly to be allowed to flow over the new section of the dam, it was necessary to harden the concrete rapidly, and this method proved very effective.

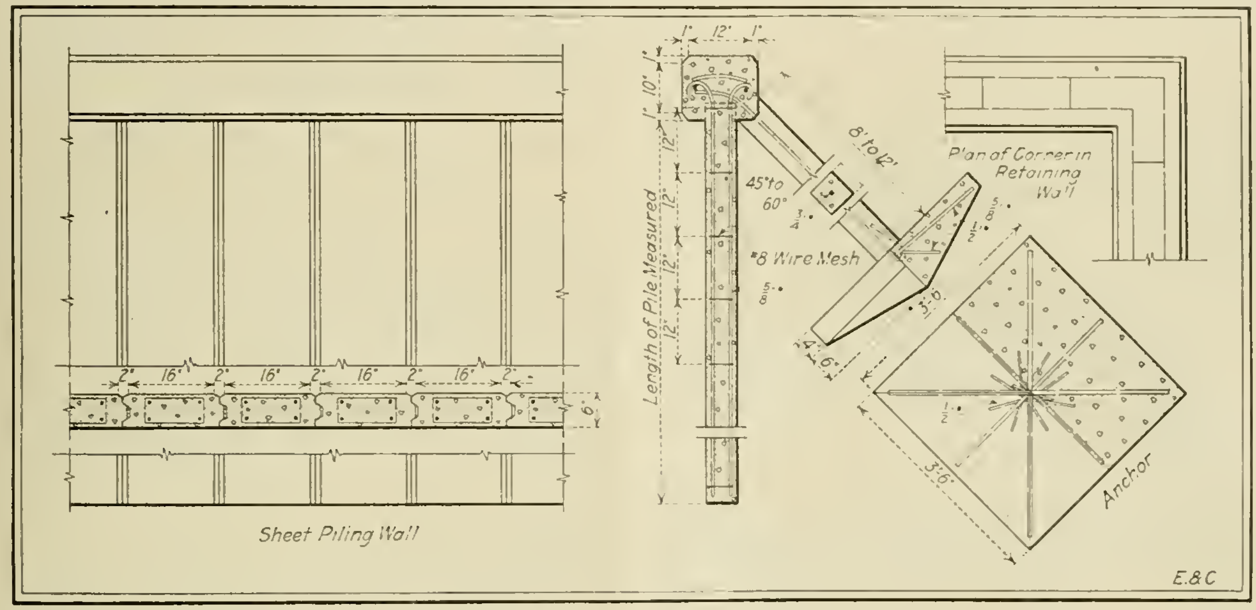
When the temperature fell below freezing, additional precautions were taken. Lighted lanterns were placed on top of the green monolith; and large improvised steam radiators, made of a few coils of 3-in. pipe, were hung close along the side of the forming; the whole was then covered with a paulin and so left for about 48 hours. Loss of heat by radiation from steel forms is much greater than from wooden forms.

Concreting was carried on without special difficulty under occasional temperatures not far from zero, and the temperature of the concrete when delivered in the forms was rarely less than 60° F. The steam coils and tarpaulins were usually kept in place for about 48 hours, when the concrete had set sufficiently to allow the forms to be taken down. The lifts, or thickness of courses, ran from 3 or 4 to about 10 ft.

Difficulties also arose from the surface freezing of the sand and gravel storage piles, on which the cold would sometimes produce a frozen crust of a foot or more, hampering the operation of the excavating bucket. This was overcome by using steam pokers, consisting of 1¼-in. steam pipe, about 10 ft. long, pointed at one end and having a few small holes. Two or three of these would be worked into the storage pile over night near its base, its surface being covered with tarpaulins. The expenditure of a very small amount of steam would heat by morning all the material within several feet of the pokers, and melt all the adjacent frozen crust.

## A 4,700 FT. CONCRETE BRIDGE.

Bids were opened last month for the construction of probably the longest concrete bridge built up to the present time in the South. The structure will extend across Charlotte Harbor, between the towns of Charlotte Harbor and Punta Gorda, Florida. It will form a very important link in one of the principal highways of the state—the Tamana Trail—which connects the east and west coasts by a road across the southern portion of Florida through the Everglades, the route originating at Tampa and terminating at Miami.

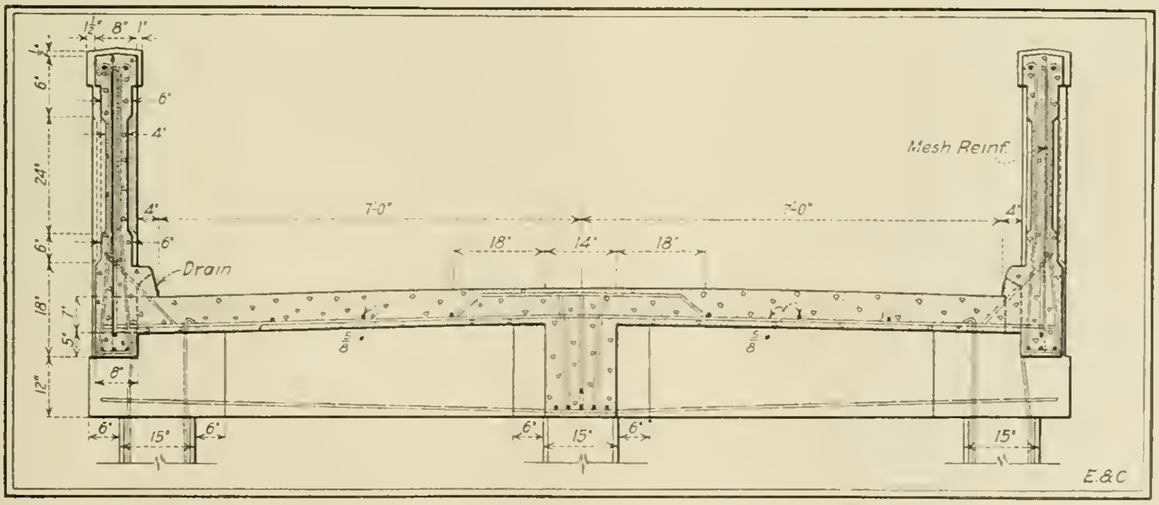


Details of Sheet Piling Wall and Anchor.

The bridge will be a reinforced concrete structure of the monolithic beam and slab type supported on concrete piles. It will be approximately 4,700 ft. long with a roadway width of 14 ft., and parapet walls about 4 ft. high. It will have a draw span giving a 50-ft. clean opening for the passage of boats. The bridge will be connected to the main land by 2,100 lin. ft. of 80-ft. wide causeway. This latter will be a hydraulic fill protected by reinforced concrete sheet piling wall. Details of the sheet piling called for by the plans are shown in the accompanying sketch. The wall will be tied to anchors located 10 ft. to 20 ft. c. to c., depending upon the height of the wall. The sheet piling will be driven to a depth of approximately 3 ft. to 5 ft. below the ground level.

The depth of water at the point of crossing for the bridge proper ranges from 5 ft. to 7 ft. below low tide. For the causeway portion the depth ranges from 0 to 3 ft. The supporting piles will be driven to a depth of approximately 10 ft. to 12 ft. below the bed of the channel.

A typical cross section of the bridge is shown in the illustration. The piles will be spaced 7 ft. centers and each bent will be 25 ft. in length. The plans for this bridge were prepared by the H. S. Jaudon Engineering Co., Savannah, Ga., and the work is being handled from their Barlow, Fla., office. The structure is to be built for the Charlotte Harbor Special Road and Bridge District of De Soto County, Florida.



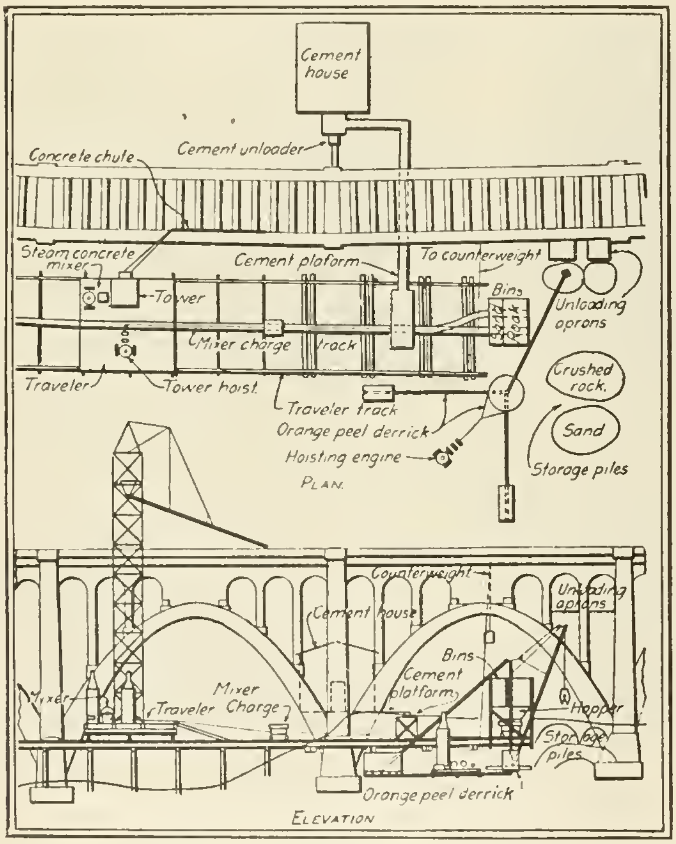
Typical Cross Section of Bridge.

## CONCRETING PLANT FOR CONSTRUCTION OF ROSALIA, WASH., BRIDGES OF C., M. & ST. P. RY.

The Chicago, Milwaukee & St. Paul Ry., last year, completed two single track reinforced concrete viaducts near Rosalia, Wash., thereby replacing a 60-ft. high, 2,100-ft. long frame trestle. The two bridges are separated by 334 ft. of embankment. The easterly structure is composed of a 107½-ft. reinforced concrete trestle abutment, a 100-ft. spandrel arch span and a 79½-ft. reinforced concrete trestle abutment. The westerly structure consists of a 77-ft. reinforced concrete abutment, three 77½-ft. and one 68⅓-ft. spandrel arches, one 58½-ft. encased steel girder and a combination trestle and U-abutment. The following description of the concreting plant used on this work is taken from the report "Efficient Methods of Handling Work and Men," submitted on Oct. 17 at the annual meeting of the American Railway Bridge and Building Association:

It was impracticable to place the plant on the track grade, and, accordingly, it was located under the westerly bridge, the layout being as shown in the accompanying cut. The crushed rock and sand were delivered in hopper bottom cars and unloaded through chutes to the ground below, and then placed in storage piles by a stiff-leg derrick fitted with 60-ft. boom and orange peel bucket. This derrick was so located as to handle the materials to the storage piles and from there to hoppers for loading in small cars for transportation to the mixer. The derrick was operated by a double drum engine fitted with a Dake swinging gear connected to a bullwheel on the base of the mast.

The mixer and tower were placed on a traveling platform that could be moved along the north side of the bridge. Most of the concrete was spouted in this way directly into the forms. The concrete was elevated and the cars containing the dry material were hauled by a hoisting engine on the traveling platform. The empty cars were pulled back to the loading hoppers by a counterweight fastened to the bridge. The cement was unloaded into a storage house immediately underneath the south of the bridge by means of an endless belt with a friction brake which enabled the lowering of the cement at slow speed to prevent damage to sacks by tearing or burning. The cement was then wheeled directly to the cars as they left the loading hoppers.



Layout of Rosalia, Wash., Concreting Plant.

The same plant was used to mix the concrete for the easterly bridge. In this case, however, the concrete was hoisted into small cars on a narrow-gage track on the north side of the main line and hauled by a gasoline locomotive. Concrete was mixed and placed in the easterly bridge for as low as 34 ct. per cu. yd. in this way, although the average was considerably above this on account of the inability to make continuous runs while concreting.

The steel reinforcement was all cut and bent on the platform at the west end of the westerly bridge and lowered into place from the track level. Portable forms were also built at the same point and handled in the same way. Water was obtained from city mains and in this way the necessity of installing a pump was avoided.

The organization of the forces was as follows:

| | |
|---|---|
| | Per mo. |
| One general foreman | $150.00 |
| One timekeeper | 75.00 |
| | Per 10 hours. |
| One carpenter foreman | $ 3.50 |
| One blacksmith | 3.25 |
| One labor-foreman | 3.00 |
| Two sub-foremen | 3.25 |
| Twenty-six carpenters | 3.00 |
| Two engineers | 3.00 |
| One engineer (gasoline) | 2.50 |
| One fireman | 2.50 |
| Ten carpenter helpers | 2.25 |
| Twenty-four laborers | 2.00 |

The size of the crew varied considerably on account of the difficulty in obtaining men and on account of some delay in obtaining material at various times. During the progress of the work the average traffic was eight passenger and about twelve freight trains per 24 hours. There was an average of four passenger and four freight trains on the Northern Pacific track under the easterly bridge; eight passenger and four freight trains on the Spokane & Inland Empire tracks under the westerly bridge and heavy team and automobile travel on the state highway, so that it was necessary to provide special falsework in each case to avoid blocking traffic.

The total amount of concrete placed was 5,924 cu. yd., the average cost per cubic yard for labor and material being $7.56. The total amount of reinforcing placed was 960,000 lb. at $1.80 per 100 lb.

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## SOME DETAILS OF NEW STREET LIGHTING SYSTEM OF POCATELLO, IDAHO.

The city of Pocatello, Idaha, awarded a contract last month for the construction of a street lighting system. The installation, in general, will follow standard practice. Some of the details, however, are of particular interest.

The system is arranged in three circuits, and series burning, rather than multiple, was decided on as better adapted to local conditions.

Alternate proposals were asked on cast iron ornamental standards, and those with pressed steel shafts. The successful contractor bid on the pressed steel only. The post on which the bid of this contractor was based is manufactured by the Union Metal Manufacturing Co. of Canton, O.

A height of 12 ft. from sidewalk to center of globe is specified for the post. This is rather less than in many other installations, but the streets of Pocatello are only 60 ft. wide, building line to building line, with 40-ft. roadways, and the 12-ft. post was decided on as being in proportion with these widths. As the primary object of the installation is to illuminate the streets and sidewalks, the acorn-shaped outer enclosing globe was selected, as giving the best diffusion of light.

It is proposed to try out lights of different candle powers, until the best results are obtained. To this end the "Mogul" sockets were specified. Absolute cutouts, while not considered absolutely essential to the successful operation of the system, were adopted as providing an additional precaution.

Discussion has brought out the fact that many cities are finding that their street lighting is being outshined to some extent by the brilliant advertising signs and outside illumination of the business houses and theaters. For a city of the size of Pocatello (17,000) there is quite a bit of this, and it is proposed for the present to use no greater candle power than is necessary for police protection and general utility after the advertising illumination is turned off for the night. Pocatello is essentially a railroad town, with many trains arriving between midnight and morning, and all night burning is proposed for the new installation. It is figured that this lesser candle power will amply meet the needs of the residential district, and will cost much less in current supplied.

The lighting system will require 355 ornamental lamp posts of the design shown in Fig. 1. These posts will be installed on and along the curb line, and connected with the underground cable system fed by constant current 6.6 ampere aerial supply circuits. The electricity will be obtained from the Idaho Power Co., which has a generating plant on the Snake River at American Falls, Idaho, about 25 miles west of Pocatello.

The underground cable will be a No. 6 B. & S. G. solid single conductor copper cable, with a ¼-in. varnished cloth insulation, 5/64 in. lead sheath, bedding of saturated jute, ungalvanized double steel taped armor, and sewing of saturated jute over all. It must stand a test of 17,000 volts before installation and 14,000 volts after installation between copper conductor and lead sheath for a period of five minutes. Fig. 2 shows details of the insulation of the armored cable entering absolute cut-out.

The cable to be installed in the posts for connecting the lamps with the underground system will be No. 8 B. & S. G. solid single conductor copper cable with a ¼-in. 30 per cent Para rubber insulation and tape and braid covering. It must stand the same test across the insulation as the lead-covered cable.

The armored cable will be buried in the ground just below the concrete sidewalk or street pavement. If parking spaces are left it will be placed not less than 12 in. below curb grade and there will be not less than 3 in. of earth between the cable and curb. In placing the cable under the sidewalk, just inside, it is figured that air-hammer methods will be adopted in chipping the sidewalk. The crease at the inside of the curb probably will afford one line of cleavage.

The cable will be run beneath all curbing rather than through it and will enter the handholes beneath the lamp posts in a horizontal position, being concreted into the handhole walls and terminating in a G. & W. combination pothead and series cutout mounted within the base of the post on lugs or brackets.

The system, as mentioned previously, will be arranged in three circuits or loops. The two terminals of each circuit will be brought into a terminal handhole built into the concrete sidewalk, or built of concrete with walls not less than 6 ins. thick in case they are located elsewhere than under the sidewalks. The inside dimensions of this handhole will be 12 in. x 14 in. x 9 in. deep. A 3-in. conduit will lead up to the terminal pole. The handholes will be covered with a 1-in. iron plate set flush with the sidewalk.

The handhole under each post will have walls at least 6 ins. thick and inside dimensions of 12 in. x 12 in. x 9 in. deep. The handhole will serve as a junction box for making connections to the post and as a foundation for the post. When in concrete sidewalks they will be made flush with the sidewalks. When elsewhere their outside dimensions will be 1 in. larger on all sides than the base of the post.

In all handholes the lead sheaths of cables running in either direction will be banded together so that the cable sheath will form a continuous electrical conduit around the circuit. The lead sheaths will be grounded at the terminal of each circuit and twice between terminals at approximately equal distance. Grounding is to be effected by a cast iron plate or by approved carbon filled grounding device buried below the permanent moisture line and connected to the cable sheaths by No. 2 B. & S. G. copper wire. If a cast iron plate is used, it will be not less than 12 in. x 18 in. x 1 in. and will be buried with not less than 5 in. of crushed coke above and below it. The ground wire will be bolted and soldered to the plate and installed in an iron pipe.

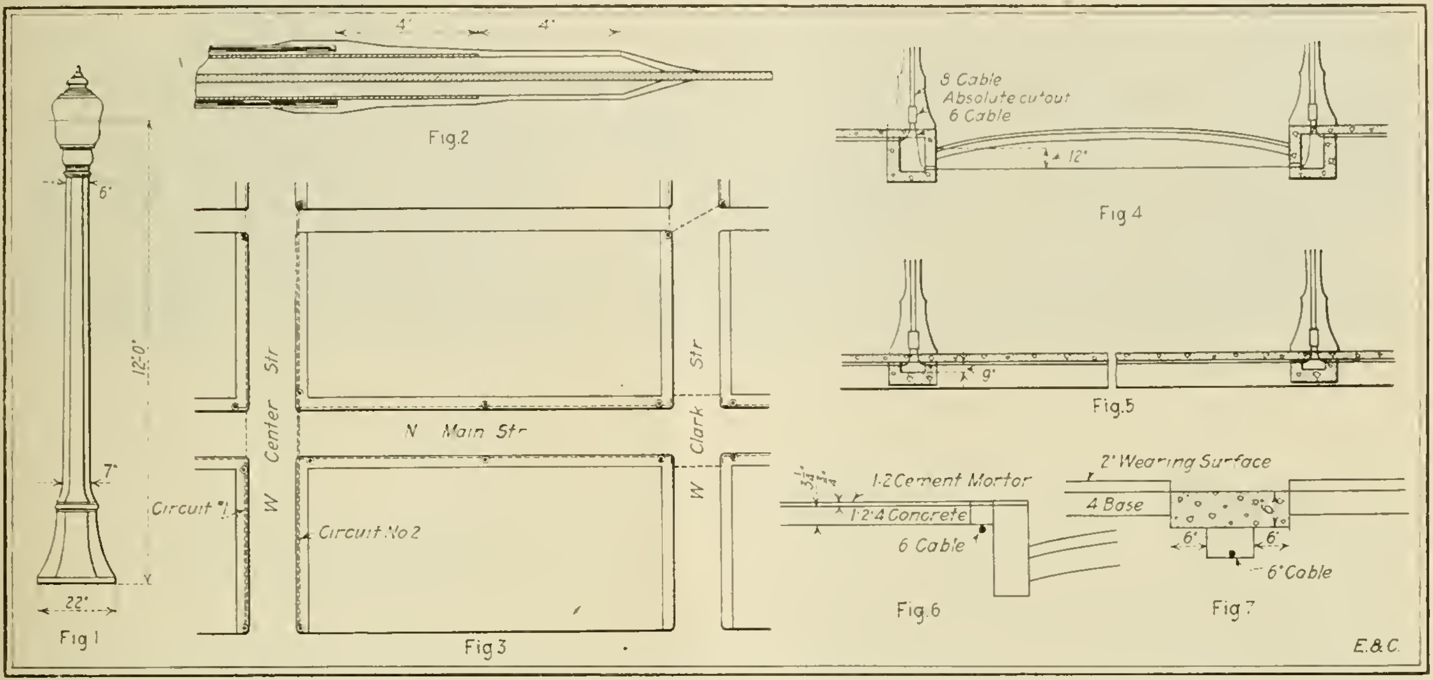


Fig. 1—Type of Lighting Unit. Fig. 2—Insulation of Armored Cable Entering Absolute Cut-out. Fig. 3—Plan of Typical Cable Installation. Fig. 4—Cable Installation at Street Crossing. Fig. 5—Cable Installation Along Curb. Fig. 6—Method of Pavement Replacement Along Curb. Fig. 7—Method of Pavement Replacement at Street Crossing.

The accompanying sketches show some details of the system. Fig. 3 is a plan of a typical cable installation. Fig. 4 shows the handholes and method of crossing street. Fig. 5 is a cable installation along curb, and Figs. 6 and 7 show method of pavement replacement. In this latter work the earth will be backfilled upon and around the cable in layers not to exceed 4 in. Each layer will be thoroughly tamped before placing the next one. The concrete foundation for the pavement will extend for a distance of 12 in. wider than the width of the trench, giving a 6-in. bearing in the undisturbed earth on either side.

Bids for the construction of the street lighting system were opened on Oct. 26, the contract being awarded to the Pocatello Electric Supply Co., Pocatello, at $51,514. The unit bids on this work are shown in Table I. The armored cable, cutouts, Novalux lighting unit, etc., will be supplied by the General Electric Co. through its Salt Lake City house. The system will be installed under the direction of J. H. Giles, city engineer.

TABLE I.—BIDS RECEIVED OCT. 26 BY CITY OF POCATELLO FOR INSTALLATION OF A STREET LIGHTING SYSTEM.

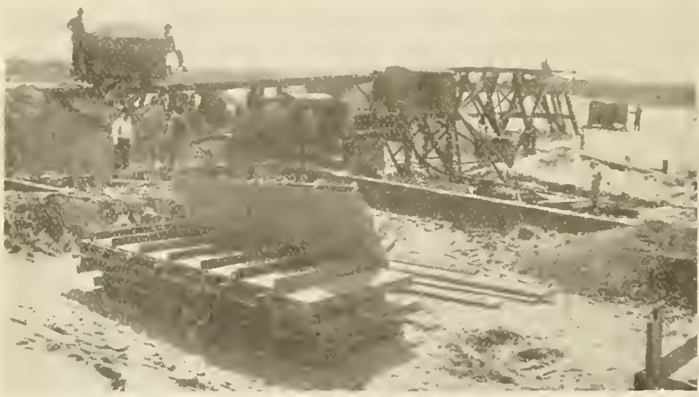
| | Pocatello Elec. Sup. Co., Pocatello. | NePage-McKinney Co., Seattle. | Eardley Bros., Salt Lake City. | Reardon & Son, Butte. | Bardsen & Lery, Pocatello. |
|---|---|---|---|---|---|
| Posts, C. I., 355 | ..... | $51.89 | $48.80 | $50.19 | $51.00 |
| Posts, Pr. St., 355 | $35.61 | 51.00 | ..... | 57.00 | 51.00 |
| Cut-outs, 355 | 4.03 | 6.55 | 5.70 | 5.97 | 3.20 |
| No. 8 cable, 7,900 lin. ft. | .18½ | .20 | .19½ | .33 | .20 |
| No. 6 cable (a), 30,230 lin. ft. | .606 | .56 | .64 | .83½ | .79 |
| No. 6 cable (b), 44,425 lin. ft. | .418 | .45 | .50½ | .54 | .77 |
| Terminal poles, 3 | 75.30 | 150.00 | 87.70 | 98.00 | 75.00 |
| *Salvage, 42 standards | 27.00 | 15.00 | 30.00 | 15.00 | 14.75 |

*This item covers the purchase by the bidder of 42 standards at present used by city for cluster lights.

## A MATERIAL HANDLING PLANT FOR DIFFICULT CONSTRUCTION CONDITIONS.

The resourcefulness of a contractor in designing a material handling plant to efficiently serve difficult construction conditions is exhibited in an installation recently made by John F. Rahn, building contractor, East Chicago, Ind., for building a large box factory for the Indiana Box Co.

The site for the plant, including a large lumber yard, borders on the Indiana Harbor Canal and comprises several acres of white sand, the surface of which is only a few feet above the water level of the canal. A railroad switch, owned jointly by the E. J. & E. and Indiana Harbor Belt Line Railways extends along one side of the tract. On this a large quantity of sand was hauled and the surface of the entire area raised several feet with the sand fill. The conditions confronting the contractor therefore was a large area of loose sand over which it would have been difficult to haul material with teams and wagons.



Inclined Track and Mixing Plant.

Another View of Plant Showing Water Point System.

The structures comprised a main building 120x184 ft., a power plant 60x80 ft., a saw-filing house 18x40 ft., and an office 26x32 ft. Owing to the loose sand fill it was necessary to construct comparatively deep side walls and foundation piers, requiring a large quantity of concrete. The soft nature of the ground also made the most practical design of plant one in which all concrete was mixed at a single point from which it was wheeled to the forms. The mixing plant was therefore located close to the ends of the main building and power plant and about 160 ft. from the railroad switch. An inclined track 200 ft. long with its inner end 10 ft. above ground was constructed at right angles with the switch and about 20 ft. distant from the mixer. All sand, stone and brick required in the construction work was hauled up this incline in a car of 4 yd. capacity by means of a cable operated by a gasoline driven hoist placed ahead of the inner end of the incline, the grade being sufficient to return the car to loading position by gravity. This arrangement permitted the sand and stone to be discharged in piles very close to the mixer and the brick deposited along the incline at points nearest to where they were needed.

This contractor uses "The Standard" low charging mixers and hoists and Novo engines exclusively in all of his construction work. On this job the plant consisted of a 10-ft. "Standard" low charging mixer, a Standard hoist with 4 HP. Novo engine mounted and housed on a truck for operating the cable, a 4 HP. Novo engine mounted on skids and housed midway between a diaphragm pump and "Standard" hoist so that either can be operated with this engine, a water point system for obtaining a water supply from the sand, and a hand winch and cable for shifting cars.

The accompanying illustrations show the small amount of equipment used and how it was placed to form an efficient plant. By elevating the pumping equipment the contractor was able to make use of a diaphragm pump, employed by him in general foundation work, to pump water into a barrel from which the mixer could be supplied by gravity. The 4 HP. gasoline engine and hoist have ample power to handle a 12,000-lb. load up the incline. At the loading switch two cars are shifted at a time by means of the hand winch and cable and are kept spotted so that material can be shoveled directly into the 4-yd. hopper car without rehandling. By the use of the elevated inclined track sand and stone were piled high close to the mixer, requiring far less hand wheeling than would have been possible with material delivered by teams and wagons. The entire operation of this plant is highly efficient and it demonstrates what can be accomplished with light, portable, inexpensive equipment in difficult construction conditions by a resourceful and competent operator.

## COST KEEPING METHODS FOR CONCRETE CONSTRUCTION.

The Ferro-Concrete Construction Co. of Cincinnati, O., one of the largest concerns in the country specializing in the erection of reinforced concrete buildings, has developed an excellent system for keeping cost records of its work. The following outline of the methods employed are taken from a thesis prepared by Harry J. Gould, cost engineer of the company:

**Pay Roll**—The present system brings a weekly pay roll showing the man's number, his name, hours, rate and amount. Cards are made up daily, on which the timekeeper notes in symbols what each man does. The timekeeper makes a round of the job and as he finds each man he enters the symbol denoting his work at that time. By making several rounds of the job and by noting the time when important changes are made, such as when concrete starts or stops, when all floor steel is laid, etc., he can get very close to the correct time for each item of work done by each man that day.

On checking his men out at night the timekeeper notes the total hours for each man on the daily card and later transfers the hours to his time book or checks with the clock card. The cards are sent to the main office daily. At the end of the week a pay roll sheet is made out and sent in. This, with the cards, gives the office complete information as to the money spent for labor on each item.

**Symbols**—The symbols used are mnemonic in character and divide the work in convenient units for recording. In the code the main divisions are capital letters, as "F" for Forms, "C" for Concrete, etc. Each is subdivided into five headings, using vowels a, e, i, o, u. These are used in the order of sequence of work. In general "a" is for equipment, "e" for unloading material, "i" is the first operation and "o" the second operation, with "u" for the final one, as cleaning up rubbish, etc.

These general classifications apply to every job, and special ones are also used for unusual cases on special work, a list of which is furnished by the office, though the timekeepers are instructed to originate such characters as they require in case of changes or unexpected conditions arising. These are explained on the daily card on which they first occur. Having the cost of work on each of these symbols, the quantity of work is needed to deduce a unit cost of each item.

**Weekly Report of Work**—At the start of the job the engineering department analyzes the estimate, or makes up a new estimate when necessary because of changes in design, and divides the work in such units as will be built separately. This will show the quantity of each class of work in a whole floor, if not too large, or in a certain clearly defined section of a floor which is a definite stopping place in the progress of the work.

On the close of a week's work the timekeeper notes the status of the work in parts of these units. Thus: "All footings concreted and wrecked; basement walls, forms complete, concrete N. & E. sides; columns, forms for 10; first floor, forms 1-6 complete," etc. With these notes he can go to the schedule of quantities and take off readily the most of these items for his quantity report. Generally he will have to figure some quantities, as excavation, which is impossible to schedule to advantage, also cement finish, basement floors, sills, etc. These quantities can be taken from the plans or from actual measurements of the work.

Where the job is subject to numerous changes and extras the quantities must be figured on the job and the scheduled quantities used only as a check. This report of quantities is approximate and subject in a certain measure to the timekeeper's judgment. This is impossible to eliminate. If every board be figured in forms actually erected, there are still more uncertain quantities. For instance, if forms for 20 columns are standing at the end of the week they may be anywhere from 30 to 80 per cent complete, depending on ledgers, plumbing, clamping, cutoffs, etc. In this instance, and in many others, the judgment of the timekeeper or foreman must be used. Suppose the amount of first floor forms be estimated too low. This is treated as an estimate purely until the whole first floor is complete, perhaps a week later, and a complete report on the entire unit is in. If the estimate shows a tremendously high or abnormally low cost the timekeeper's attention is called to the fact that his judgment may have erred, and he and the foreman are asked to watch the item on the following week.

**Office Work**—As the daily cards come in they are totaled as to money spent for each symbol. The sum of these totals should equal the pay roll, and an arbitrary limit of ½ of 1 per cent has been set as an allowable error. It is found that the majority of the work comes well within the limits, and careful investigation of errors beyond this limit and a report of same to timekeepers has the effect of keeping them keyed up to the importance of accuracy. The errors are thrown to the item of "G," which stands for "General Expense,". and includes regularly timekeeper, watchman, water boy, etc. It is found errors are not cumulative, but generally offset each other very closely.

Record of the labor on each job is kept in separate folders on loose leaf sheets 8½x11 in., ruled in three general columns. In these columns are entered under the proper symbols the date and amount spent each week on that item and the total brought down to date in red ink. The amount of work done is also entered and a unit cost for the week figured. Then from the total work to date and the total cost the total unit cost to date is figured.

The total costs of the three main divisions of the work (concrete, forms and steel) are obtained each week by summing up these various units in their proper relation. This requires care and the execise of good judgment in weighing the miscellaneous items. For instance, equipment and perhaps unloading costs come in at the very start before any actual work is erected. The cleaning up items may come in only after considerable work has been done. In the former case the practice is to estimate a unit for a few weeks, then use a fractional part of the equipment cost, and in case of forms a fractional part of the unloading also. An estimated figure of what the cleaning up item will likely amount to is used until it begins to come in regularly enough to actually figure. Such estimates are always indicated by an abbreviation, "Est," or by the fractional part used, as "⅓."

**Weekly Labor Summary**—A report of these weekly unit costs and the total unit costs is made up each week. It also shows the totaling of the main divisions, comparing same with the previous work, or with the estimate. Notes and comments are freely used, and unusual items are underscored in red ink for special attention. These are made out in the same symbols as the timekeeper's code, so that the uninitiated would not be able to decipher it intelligently. The amount of cement used per yard and any other material items which may have been specially checked will appear on this report also. One copy goes direct to the superintendent on the job, another to the officers of the company for inspection. These reports are referred to in the weekly executive meeting, in which all current work is checked up as to time, delays, cost of work, etc.

**Curves**—On large jobs it has been found advantageous to use curves to show the weekly fluctuation of the main items of labor. The estimated labor cost is a straight line; when the curve goes above this line the company is losing money, when below it is saving over its estimate. These have proven very satisfactory, but are only used on large jobs where the work extends over several months. The small jobs are complete before the items of equipment, unloading, etc., can be properly proportioned.

**Recording Materials**—The daily report shows the receipts of all items at the work. It is made out and sent to the main office daily by the timekeeper. The name of dealer, quantity and description are given, also price, if this has been left to the job to buy. On receipt of these daily reports at the main office the dealers' bills are O. K.'d by the purchasing department. These bills then go to the cost department for entry; this entry must be made promptly to avoid delay in payment and a possible loss of discount. Hence they are entered at once in a loose leaf ledger by jobs, showing the dealer's name, quantity, description, price, gross bill, freight deductions and net bill. The bill is initialed and passed along to the bookkeeper for further record and payment. Periodically the cost ledger and the bookkeeper's ledger are balanced and any errors or omissions corrected.

From this cost ledger the items are transferred to the folder records for each job and each entry is classified under its proper heading or headings. Thus, cement bought and the freight is in one column, the hauling in another; freight on empty sacks, credits for empty sacks, testing, etc., are separate items on each job. The amount and cost of each material is thus readily available for comparison with the estimate or for figuring costs.

**Analysis of Estimate**—As made up for bidding, an estimate rarely is divided so that the amounts of either labor or exact materials are available without further analysis. This analysis is made by the cost department soon after the contract is signed and shows the labor items by symbols, divided as the work will be done, giving estimated quantity and estimated unit cost. The materials are totaled and include hauling, miscellaneous expense, etc., all listed separately in such separate headings as are found by experienec to be most advantageous. Both of these, but more especially the labor, may vary from the actual estimate and be based on what experience indicates the work should be done for. Hence, if mistakes be made in the original estimate, the job is still placed on its merits.

The net variance from the estimate when a saving is carried as a contingency item to care for unexpected conditions, delays, etc. This analysis may be carried into too little or too great detail until the most advantageous divisions are found. They soon develop into a standard form, so that this question is not long a troublesome one.

A comparison of actual results and those previously estimated is now possible, and a sheet is prepared approximately every two months, showing what each item of labor was expected to cost, both in units and total, and what it has cost. The total saving or the loss is figured and entered for each item or group of items. This brings in all materials and all the labor, so a total net saving or net loss gives the true status of the job on that date.

In making this comparison allowance must be made for materials on hand for future work, and requires a fairly accurate knowledge of job conditions at the time. This statement goes to the job superintendent and also to the officers of the company for inspection and criticisms. Its totals show whether the job is making or losing money, and by looking through the items the source of the profit or loss may be determined.

Final Analysis—At the close of a job, after all claims and delayed bills are adjusted, the cost of each item in the estimate is figured in more detail. The bi-monthly statements do not show what part of the concrete materials bought have been used in the basement floor, for instance. Materials for such items are separated from the concrete work, priced and entered as the material cost on these items, from which the unit material cost is figured. Likewise, a proportionate part of the labor on equipment, unloading and cleaning up is added to the direct labor cost. The official now has a total labor and total material charge on each item of the original estimate, and by comparing the estimate with the actual cost he can find the profit or loss on each more definitely than in the bi-monthly reports.

These final analyses are entered in the permanent cost record in detailed form for future reference. On this record sheet are also figured the actual cost per sq. ft. of floor of the concrete only, and then of the various subcontract branches. A short description of the job, the prices of main materials and labor, and notes regarding job conditions make this a valuable record for later reference.

Personnel—This system of recording costs, as now operated, requires no additional men on the jobs. It does require some ability in reading plans on the part of the timekeepers, which has brought the company to favor young engineers for such work. Should they show executive ability, training in timekeeping makes them the more valuable as foremen or superintendents.

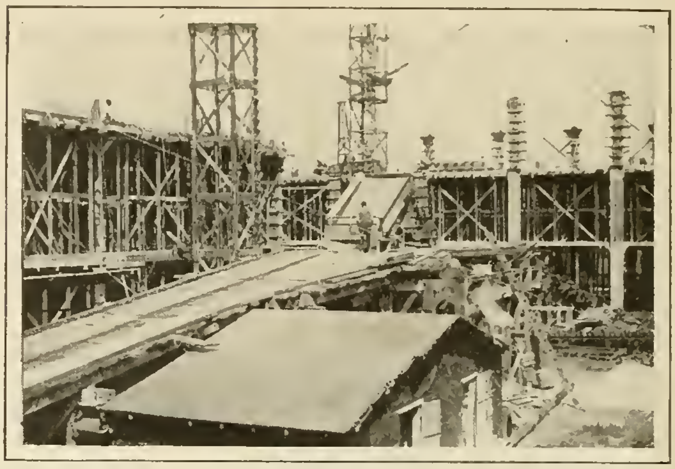
The office work at present requires the full time of two men. Their reports are inspected and supervised by the cost engineer, who takes up any unusual items with the superintendent and the office.

## INCLINE AND PLATFORM FACILITATE RAPID UNLOADING OF TRUCKS.

Many building contracts are figured on a time basis and the speed and increased efficiency with which cement, sand, slag, gravel and crushed stone may be handled by the use of motor trucks, has saved large sums for the contractors.

Very often on big jobs, special devices for loading and unloading have been constructed to facilitate the operation of the trucks and a striking example of this is the use of a fleet of nine White power dumping trucks owned by the Cleveland Builders' Supply Co. on the construction of the new $500,000 building for the Richman Bros. Co., Cleveland.

The structural work of this building is largely concrete and many tons of sand, cement, and gravel are mixed daily. In order to do this work as speedily as possible, the contractors have built a platform of heavy wooden beams on a level with the second story of the structure. Leading up to this platform there are two inclines built of heavy planks and with a grade of above 10 per cent. The White trucks with their 5-ton load are driven up the incline on one side of the platform. The loads are dumped through an aperture in the platform and the trucks driven across the platform and down the incline on the other side.



Incline and Truck Unloading Platform at Richman Bldg., Cleveland.

In this way the trucks are kept running continuously and no time is lost in backing and maneuvering around to find the most advantageous place for dumping.

## FORMWORK TABLES FOR REINFORCED CONCRETE BUILDINGS.

The recently issued 23rd annual report of the Chief State Factory Inspector of Illinois for the year ending June 30, 1916, contains an excellent article by Mr. Ernest McCullough, chief engineer of the Fireproof Construction Bureau of the Portland Cement Association, on the use of forms in the erection of reinforced concrete buildings. In his article Mr. McCullough gives the following tables for formwork. Table I contains a description of the slabs with a number given to each slab. Reference is made to slab numbers in the tables following instead of to a slab thickness.

TABLE I.—SLAB NUMBERS.

| Slab numbers | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slab thickness in in.— | | | | | | | | | | | | | | | | | |
| Solid slab | 3 | 4 | .. | .. | 5 | .. | .. | 6 | .. | 7 | .. | 8 | .. | 9 | 10 | 11 | 12 |
| Combination tile and concrete | | 6 | 7 | 8 | .. | 9 | 10 | 11 | 12 | 13 | 14 | .. | 15 | .. | .. | .. | .. |

TABLE II—TABLE OF POSTS FOR CENTERING.

3 in. by 4 in. solid, to be spaced 4 ft. by 6 ft. or less, under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, braced in four directions every 7 ft.

To be spaced 4 ft. by 4 ft. or less under slabs 11, 12, 13, 14, 15, 16, 17, and 4 ft. apart under girders or beams.

4 in. by 4 in. solid, or T post of 2-2 in. by 4 in., properly spiked.

To be spaced 6 ft. by 6 ft. or less, under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, braced in four directions every 8 ft.

To be spaced 4 ft. by 6 ft. or less, under slabs 11, 12, 13, 14, 15, 16, 17, or 5 ft. apart under girders or beams.

6 in. by 6 in. solid, or T post or 2 in. by 4 in. and 2 in. by 6 in., properly spiked, braced in four directions every 8 ft.

To be spaced 6 ft. by 6 ft. or less, under slabs 12, 13, 14, 15, 16, 17, or 6 ft. apart under girders or beams.

It is important that the above requirements for length of posts be observed. They may be of any length to conform to clear height but must be tied in four directions so the greatest length from end to tie shall be not more than above stated. The ties may be horizontal or diagonal and should be well secured by nailing.

It is important that the posts rest at the lower end on a plank in order to distribute the load over the floor. Use a 2-in. by 12-in. for spacing of 4 ft. by 6 ft.; a 3-in. by 12-in. for spacing of 4 ft. by 6 ft. and 4-in. by 12-in. for spacing of 6 ft. by 6 ft. These planks are parallel with and directly under the girders carrying the joists.

Posts must be full length and must not be used with blocks under the lower end. Wedges when used should be in pairs and thin. Do not drive nails through wedges for this interferes with adjustment. To prevent the working loose of wedges drive a nail into the plank or fasten a block to the plank, bearing against the heavy end of each wedge.

Care should be taken to have posts as nearly as possible directly over posts below in a vertical line from story to story.

All posts should be plumb. This is important.

TABLE III.—SIZE AND SPACING OF JOISTS ON 4-FT. SPAN.

| Slab number. | Size, in. | Spacing, in. | Slab number. | Size, in. | Spacing, in. |
|---|---|---|---|---|---|
| 1 | 2 by 4<br>2 by 4 | 16<br>24 | 16 | 2 by 6 | 24 |
| 2 to 15 inclusive | 2 by 6 | 24 | 17 | 2 by 6 | 24 |

TABLE IV.—SIZE AND SPACING OF JOISTS ON 6-FT. SPAN.

| Slab number. | Size, in. | Spacing, in. | Slab number. | Size, in. | Spacing, in. |
|---|---|---|---|---|---|
| 1, 2 | 2 by 6<br>2 by 8 | 16<br>24 | 7, 8 | 2 by 6<br>2 by 8 | 12<br>24 |
| 3 | 2 by 6<br>2 by 8 | 15<br>24 | 9, 10, 11, 12, 13 | 2 by 6<br>2 by 8 | 12<br>24 |
| 4, 5, 6 | 2 by 6<br>2 by 8 | 14<br>24 | 14, 15, 16, 17 | 2 by 8<br>2 by 8 | 24<br>18 |

Flooring over joists may be $\frac{7}{8}$-in. thick (1 in. dressed) on spans of less than 21 in. It must be a full 1 in. ($1\frac{1}{4}$-in. dressed) on spans of 21 in., and 24 in. All joists to be crossbridged every 4 ft.

TABLE V.—MINIMUM SIZES OF GIRDERS ACROSS POSTS ON 4-FT. SPAN. SPAN OF JOISTS 4-FT. OR 6 FT.

| Slab number. | Sizes, inches. | Slab number. | Sizes, inches. |
|---|---|---|---|
| 1, 2 | 2 by 10, 3 by 8, or 4 by 6. | 15 | 3 by 10, 4 by 8, or 6 by 6. |
| 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 2 by 10, or 3 by 8. | 16 | 3 by 10, or 4 by 8. |
| 14 | 2 by 10, 4 by 8, or 6 by 6. | 17 | 2 by 12, 3 by 10, or 4 by 8. |

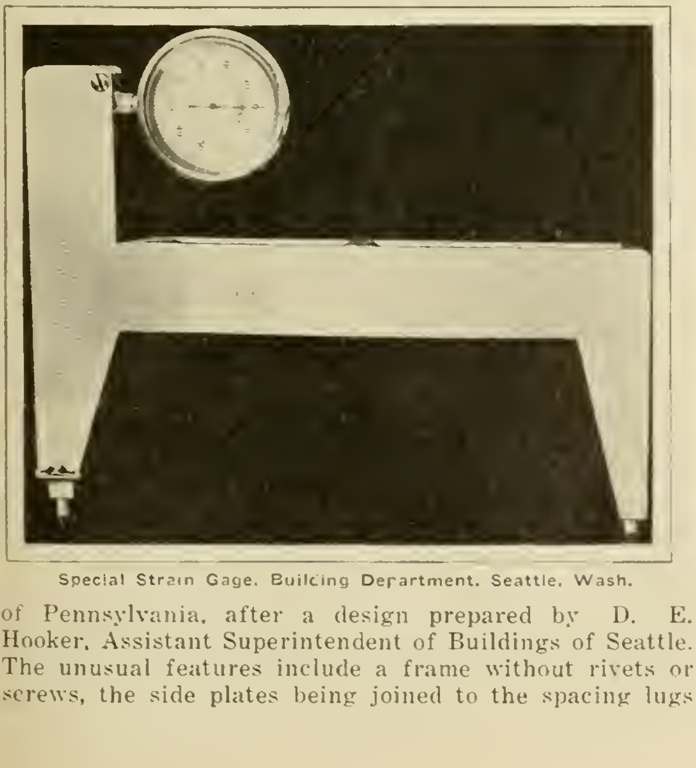
TABLE VI.—MINIMUM SIZES OF GIRDERS ACROSS POSTS ON 6-FT. SPAN. SPAN OF JOISTS 4-FT. OR 6-FT.

| Slab number. | Sizes in inches. |
|---|---|
| 1 | 2 by 12, or 3 by 10. |
| 2, 3 | 3 by 12, 4 by 10, or 6 by 8. |
| 4, 5, 6, 7, 8, 9 | 2 by 14, 3 by 12, 4 by 10, or 6 by 8. |
| 10 | 2 by 14, 3 by 12, 5 by 10, or 6 by 9. |
| 11 | 4 by 12, 6 by 9, or 7 by 8. |
| 12, 13 | 3 by 12, 5 by 10, 6 by 9, or 7 by 8. |
| 14 | 4 by 12, 5 by 10, or 6 by 9. |
| 15 | 3 by 14, 4 by 12, 5 by 10, 6 by 9, or 8 by 8. |
| 16 | 2 by 16, 3 by 14, 4 by 12, 5 by 10, 7 by 9, or 8 by 8. |
| 17 | 2 by 16, 3 by 14, 4 by 12, 6 by 10, or 7 by 9. |

Girders may be composed of several boards or planks side by side, care being taken to accurately size the pieces over bearings so they will act together. They should be spiked together and if 1-in. lumber is used with heavier stuff the thinner pieces should be inside. All girders to be braced or crossbridged every 4 ft.

## SPECIAL STRAIN GAGE FOR REINFORCED CONCRETE BUILDING TESTS.

A specially constructed strain gage is used by the Building Department of the City of Seattle, Wash., for measuring strains in reinforced concrete buildings. This gage was supplied by Prof. H. C. Berry of the University of Pennsylvania, after a design prepared by D. E. Hooker, Assistant Superintendent of Buildings of Seattle. The unusual features include a frame without rivets or screws, the side plates being joined to the spacing lugs by the electric welding process; checkered side plates to give better grip for the hands; a clearance of 3 in. to enable readings to be made on steel embedded deep in the concrete; and a specially constructed fulcrum joint for the movable leg.



Special Strain Gage. Building Department. Seattle. Wash.

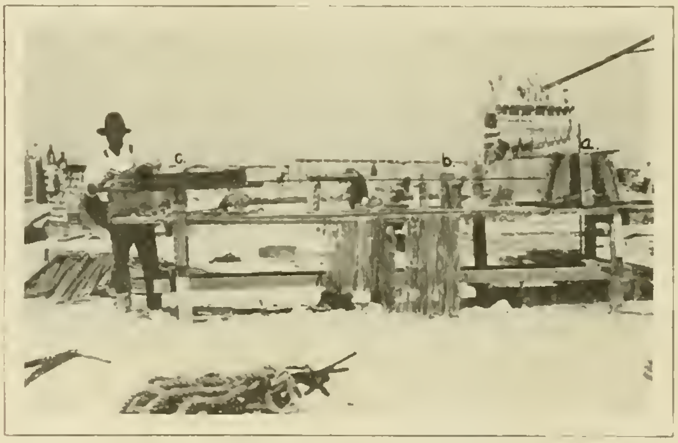
The one-piece frame is so rigid that side pressure, given unconsciously when making observations, has comparatively little effect on the readings, and there are no rivets or screws to work loose or throw unequal interior strains in the frame. The 3-in. legs allow measurements on the deepest layer of steel in four-way flat slabs and the checkered plates reduce the strain of continued reading by improving the grip of the hands on the instrument.

The trunions of the movable leg are held up into position in the notches of the frame by a spring, guarded by a cover plate. Both the spring and the cover plate are square, with a square hole in the center of each through which the movable leg passes. The cover plate is held in place by four countersunk screws, which are screwed "home" in the frame and thus have no tendency to work loose.

## TABLE FOR BENDING TIE WIRES FOR CONCRETE FORMS.

Contributed by W. D. Jones.

In the construction of a large quantity of 6-in. and 8-in. concrete walls at Los Angeles Harbor by the Merchants' Realty & Investment Co., contractors, of Los Angeles, making form ties from rolls of No. 8 and No. 9 wire proved to be an item of expense worth noting. The table and equipment shown in the photograph are the outcome of several schemes for increasing the output of a man and proved to be a considerable saving in this feature of the work.



Tie Wire Bending Table.

The outfit consisted of a table, as shown, with a revolving drum on one end; on the other was placed a 2-in. x 4-in. timber in such a manner that it could be turned about a steel pin set in a block fixed to the table. Between the drum and the 2-in. x 4-in. was placed a friction, shown at (b), through which the wire was passed in order to give the tension necessary to insure tight winding about the 2-in. x 4-in. The drum was made tapering, as shown at (a), in order that rolls of any size wire could be held.

When operating, the roll of wire was placed on drum one end passed through friction at (b) to the 2-in. x 4-in. at (c). By turning this the wire was wound about the two blocks placed on top. When the capacity of the blocks was reached wires were cut in center with a pair of bolt cutters and laid in stacks near by.

The edges of the blocks about which the wire was bent were shod with iron to insure a good sharp bend. By having pieces of 2-in. x 4-in. with blocks placed at different distances apart and arranging them to be readily removed from pin as desired, any lengths of ties could be made by simply changing the 2-in. x 4-in.

With this outfit one Mexican at $2 per 8-hour day, in 8 hours bent 800 tie wires, tied them in bundles and piled them nearby in shape to be carried to carpenters.

## I-BEAM AND CONCRETE HIGHWAY BRIDGES IN ADAMS COUNTY, INDIANA.

Highway bridges with I-beams resting on concrete abutments and carrying a concrete slab floor are used extensively in Indiana. The acompanying drawing represents one of a number of such bridges designed by R. L. Longshore, deputy county surveyor of Adams county, Indiana.

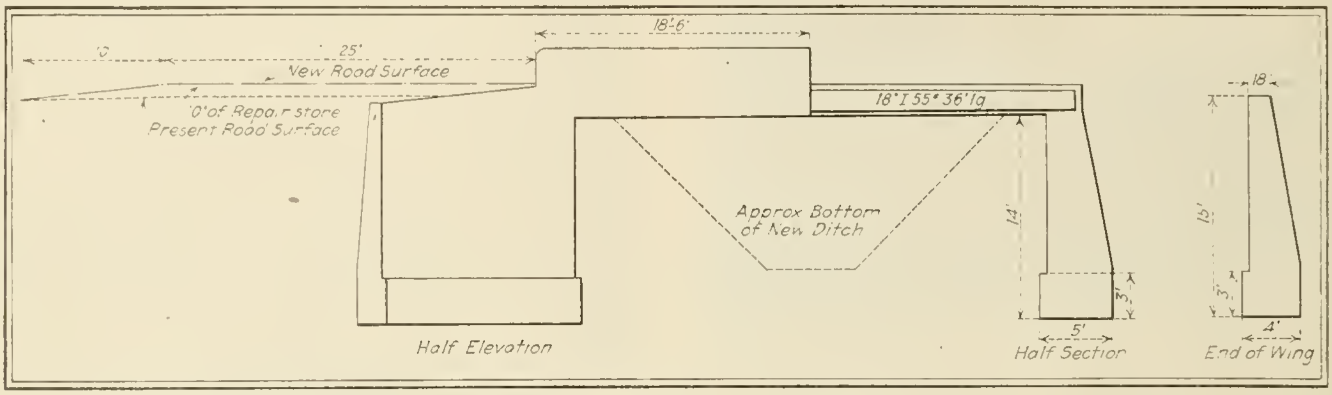


Fig. 1—Half Elevation and Half Section.

The design covers spans from 10 to 36 ft., using 9-in., 21-lb. beams for the former and 20-in., 80-lb. beams for the latter. Beams are spaced 3 ft. center to center, requiring eight beams for the 20-ft. roadway type and seven for the 18-ft. roadway.

Fig. 2—Geo. W. Gates Bridge.

The beams rest on channel wall plates placed on the top of the abutments while the concrete is green. Each beam is encased in concrete not only to prevent rust but also to take the place of the transverse bracing usually found in a bridge of this type. The beams are wrapped in light triangular mesh reinforcing, and the same weight metal extends into the parapet walls.

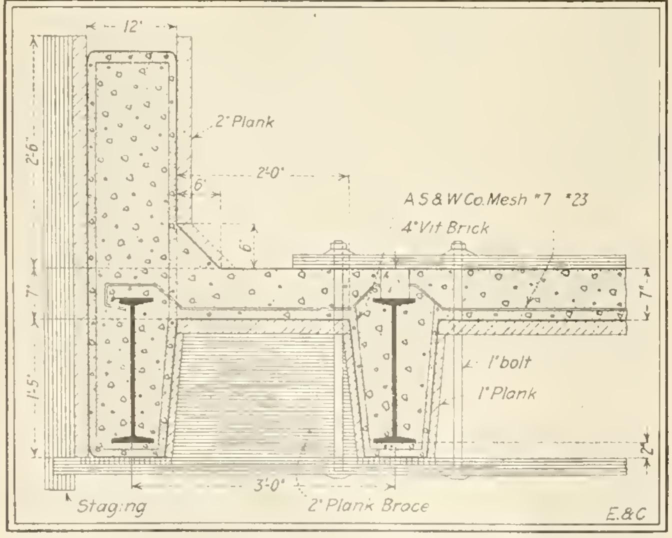


Fig. 3—Detail cf Floor and Parapet and Method of Placing Forms.

The deck is a concrete slab 7 in. thick with the top of the slab 4 in. above the beam. It is reinforced with heavy triangular mesh. The two weights of mesh are standard and misplaced reinforcement is almost impossible. Drainage is provided over the wings.

On the smaller structures the forms for the floor and beam casings are supported by heavy wire from the beams, thus requiring staging only at the parapet walls.

On the larger structures such as the one shown in Fig. 2 special methods of forming have been found necessary. As shown in Fig. 3 the forms are bolted to 2 by 4 timber supported on the beams by half paving bricks. These bricks are flush with the top of the floor and are left in place in the finished floor. The bolts are oiled to permit of easy removal and the holes are filled with cement mortar.

All concrete used is a 1:2:4 mix. Washed sand and crushed limestone are used as the aggregates. The specifications for concrete follow closely after the Pennsylvania State concrete specifications.

As shown in the drawing and photograph the road metal is carried across the bridge floor, not only to protect the slab from impact but to avoid chucks at the ends of the bridge.

No steel is exposed on the finished structure. This design has been found to be the most practicable solution for the average short span bridge in this county. It is well adapted for sites having scant head room and may be built by semi-skilled labor under ordinary inspection.

The bridge shown in the photograph was built by the Tapp Construction Co. of Fort Wayne, Indiana, during the season of 1916 at a contract price of $2,600. The plan for the forms for the structure was developed by Mr. Hermann Tapp of the above named company.

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## PERSONALS.

J. L. Lee has been appointed Valuation Engineer of the Sierra Ry. Co. of California with headquarters at Jamestown, Cal.

John Hulst, Chief Mechanical Engineer of the Carnegie Steel Co., Pittsburgh, Pa., has been appointed Consulting Engineer of the U. S. Steel Corporation with headquarters in New York City. Sidney Dillon, Mechanical Engineer of the Edgar Thomson Work, to succeed Mr. Hulst as Chief Mechanical Engineer of the Carnegie Co.

A. L. Crissinger has been appointed State Highway Superintendent of Beaver County, Pennsylvania. H. M. Dorwart has been promoted from the Superintendency of Jefferson County to the Superintendency of Potter County, where he takes the place of J. W. Frazier, who has resigned to enter private business. The state highways in Jefferson County have been placed in charge of A. B. Howard, who has been appointed a General Foreman. The vacancy in the superintendency in this county will not be filled for the present. Mr. Crissinger, who is 27 years old, has been in the service of the State Highway Department for three years, acting successfully as Assistant Foreman, Timekeeper and General Foreman. His home is in Greensburg. Mr. Dorwart is a native of Lancaster, and a graduate of Franklin and Marshall College. He has been with the Pennsylvania State Highway Department nearly five years as Transitman, Rodman, Chainman, Levelman and Draftsman. He was appointed Superintendent of Jefferson County Aug. 1.

## INDUSTRIAL NOTES.

The Standard Scale & Supply Co. has moved its Philadelphia office, warerooms and service department from 35 S. Fourth St., to a new location at 523 Arch St. The building having a depth of nearly 300 ft. extending through to 518 Cherry St. These larger quarters are necessary to take care of the various departments and stock of concrete mixers, hoisting outfits, power pumps, gasoline and oil engines, scales and trucks, as well as repair parts for engines, hoists, mixers, etc., which are carried at all branches of this company in connection with a special service department operated to give the advantage of quick service and repairs in case of adjustments or breakdowns.

The Jamestown Shale Paving Brick Co. of Jamestown, N. Y., has become a licensee of the Dunn Wire-Cut Lug Brick Company of Conneaut, O., and will make wire-cut lug paving brick. This company has been making paving brick for more than 30 years and has rebuilt its plants so they are modern, up-to-date, and fireproof. It has a daily capacity of 65,000 blocks. It operates five rectangular kilns with a daily capacity of 25,000 and a continuous kiln with daily capacity of 40,000.

Planning and Management Quarterly Issue
of
# Engineering and Contracting
Halbert P. Gillette, *President and Editor*

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## OUR PLANNING AND MANAGEMENT QUARTERLY ISSUE AND SOME REMARKS ABOUT THE ORIGIN OF "SCIENCE OF MANAGEMENT."

It has been decided to change the title of our "Surveying, Drafting and Office Quarterly" to "Planning and Management Quarterly," which is published on the fifth Wednesday of four months. A changed title seems desirable, not only to secure greater brevity of title but to indicate that this issue includes articles on cost keeping and management.

The articles on drafting and surveying naturally fall under the general head of "planning." Articles on cost keeping—of which a greater number will appear in the January issue—fall under the general head of "management."

In this connection it may be of interest to note that the expression "science of management" was coined by the chief editor of Engineering and Contracting, and was first used in a little book entitled "Cost Analysis Engineering," by Gillette and Dana, published in 1908, from which we quote:

> **Science of Management.**—The managing of industrial enterprises is still more or less of an art; but the art is fast passing through the period of evolution that produces a science. There are, unquestionably, certain underlying principles of management which can be summarized into rules or laws. These rules or laws constitute the science of management, and it is our purpose to present certain of the more important laws of management.

A year later (1909) the same authors produced "Cost Keeping and Management Engineering," a much larger book in which ten general laws and many minor rules of the science of management were formulated. Following this book there has been a veritable flood of literature on "scientific management." What we wish here to emphasize is the fact that it was two civil engineers who, through the two books above named, gave not only the first published expression of the possibility of producing a science of management but themselves offered the first comprehensive, though admittedly incomplete, code of laws of the new science.

It is difficult now to realize that it is but slightly less than eight years since "Cost Keeping and Management Engineering" was written, and that, therefore, within less than a decade a veritable revolution has occurred in respect to managerial methods.

The Taylor system of management and other systems had existed prior to the conception of the idea that a comprehensive science of management could be produced. Fred W. Taylor, himself a mechanical engineer, had "invented," to use his own designation, a new system or "art of management," by combining four old ideas into one composite plan. The "differential piece rate system of payment" was one of these ideas, but, in their "science of management," Gillette and Dana gave much greater breadth to this idea by formulating their first law of management which they entitled "payment proportional to performance." Similarly they generalized more broadly each of the four ideas that Taylor had applied, and thereto they added many others, seeking to produce not "a new invention"—as Taylor had termed his system of management—but a general science of management. It is significant of the difference of objects of these writers to note that Taylor, throughout his writings prior to 1909, repeatedly used the expression "art of management," whereas Gillette and Dana used the expression "science of management."

We do not mean to imply either that Taylor was not scientific or that he lacked sound conceptions as to scientific management. But we insist that he never attempted to formulate the broad principles of a comprehensive science of management, for he seems never to have conceived such a possibility prior to its conception by others. Taylor was a great man and his teachings have been an inspiration to multitudes of others. Similarly Wellington (author of "The Economic Theory of Railway Location") was great in an allied field, and to this day his book is a thought-compelling treatise that all engineers should study.

## WHY SHOULD NOT COUNTY ENGINEERS BECOME "COUNTY MANAGERS"?

There are 42 American cities that have "city managers" in place of mayors and aldermen, and the number of cities thus managed by civil engineers is steadily growing. What county will emulate the city of Dayton, Ohio, and be the first to make a civil engineer the "county manager," as Dayton made a civil engineer its "city manager"?

The county commission form of government is far from ideal. In rural districts the county commissioners are usually farmers who, although honest, well meaning citizens, are seldom possessed of enough technical knowledge to pass intelligently on all the engineering problems that come before them. Bridge building, road work, drainage—these are all engineering problems, and they constitute the most important things about which county commissioners must decide. Even the duties that do not involve what is commonly thought of as engineering, do involve economics of some sort, and here also the engineer is, by his education and experience, better qualified to pass judgment.

Finally, in most counties the board of county commissioners meets intermittently, and is consequently less able to give proper consideration to all matters than a "county manager." Better far one engineer in constant session with himself, studying the problems of county administration, than three men meeting once in a while to consider reports, petitions, and the miscellaneous lot of things that pile up between sessions.

We suggest that the county engineers of America might do well to organize a national association, having for its prime object the education of the public to the desirability of administration of county affairs by a county manager. We shall be glad to receive suggestions as to such an organization, and to file the names of those of our readers who favor the idea and wish to be kept informed about it.

## TEACH THE PUBLIC WHAT AN ENGINEERING EDUCATION MEANS.

One needs but to read the editorials in some of the metropolitan daily papers for a few months to realize that the expression "college education," as used by the editors, excludes engineering education. Under the title, "College Limitations," a Chicago editor asks whether "ambitious boys are not quite frequently ruined by college." He says:

> There are many minds to which the abstract is distasteful and the obsolete irritating. Not philosophy, but the application of individual

> energy to personal problems is what interests them. They are not concerned with history, but with achievement. What other men have thought about life and the record they have made of their ideas does not begin to move them as do their own reactions.
>
> They are not less valuable than those of studious nature. Quite the contrary. Resourceful, original, aggressive natures sometimes find it nothing less than torture to sit in the classroom listening to the perfunctory addresses of weary instructors, or spending the evenings in application to studies which do not interest them and which they will soon forget. They find the universities in many respects disappointing. No one who comes in contact with them has the qualities of leadership for which they long; the academic interpretations of life are liable to be meager, cut and dried. It is little wonder that enthusiasm faints and dies, that personality weakens and the initiative atrophies during the dragging four years of college life. For it does drag to the youth not constitutionally fitted for it.
>
> To depreciate education would be stupid indeed. But it may well be asked if thousands of young people are not deflected from the use of their talents and powers by too many years of study. They feel the need to do, not to think. Their power of achievement exceeds their capacity for reflection. Have they not a right to choose? Shall parents consider them ungrateful or dull because they prefer to express themselves through their first-hand contact with life instead of by means of memorizing what other men have done, thought, and surmised?

We have quoted at length to make it clear that the editorial writer had no conception of what a four-year course in an engineering college involves. It is possible that he is among those who would argue that there are engineering schools but no engineering colleges. In either case we have a point to make, namely, the desirability of adopting publicity methods that will bring about a general understanding of the nature of the training that our engineering colleges give.

While we grant that many of the defects of the classical colleges are to be found in the engineering colleges—such, for example, as the spending of too much time memorizing data and too little in forming mental habits of the most useful kind—still, it will be conceded by most well informed men that a scientific education is preferable to a classical education, both in respect of training the thinking faculty and in respect of arousing interest in the college work.

Let us improve our engineering colleges by all means, but let us, at the same time, teach the public more about the possibilities of applied science, which is engineering.

## MOTOR TRUCKS ON PRIMARY TRIANGULATION.

Motor trucks were used by the U. S. Coast and Geodetic Survey on its recently completed work of observing on an arc of primary triangulation which extends 630 miles from northern Utah, northwestward to the Columbia River in northeastern Oregon, thence westward down the Columbia River to Portland, Ore. This is the first time trucks have been used in primary triangulation and they proved so successful that all other surveying parties engaged on similar work will use this means of communication. The trucks carried the party and outfit to the base of the peaks on which observations were made with the theodolite. The camp equipage and instruments were carried from the truck to the top of the peak by horses or by the members of the party.

As a result of this survey about 100 stations have had their latitudes and longitudes accurately determined and have been substantially monumented with concrete blocks, which have inscribed metal tablets. Accurate elevations of numerous mountain peaks were determined by this survey.

Most of the observations were made at night by use of acetylene lamps. The longest distance observed was 134 miles, between a peak in northern Utah and a second peak in southern Idaho. The lamps were cared for by trained light kepers. In spite of the rugged country over which this work was carried there were no serious accidents to the members of the party in either of the two seasons during which observations were made.

**Securing Good Impression With Rubber Stamp.**—Rough surfaced paper can be smoothed down with a piece of sandpaper so that a rubber stamp will make a satisfactory impression. This scheme is particularly useful in printing on maps, drawings and other documents for filing purposes.

## INVENTING AN INVENTOR OR CREATING A COMPOSITE GENIUS.

By Halbert P. Gillette.

There is a little shop in Rochester, N. Y., that is fascinating to every man that enters it. None enter save inventors, would-be-inventors, and their "angels." As this little shop is both the cradle and the graveyard of inventions, it is a place of uncommon interest.

At one of the benches in this little shop stands a long stoop-shouldered man and at intervals he stops his filing or fitting and holds up a piece of metal at which he squints critically through steel-rimmed spectacles. This man has himself invented innumerable appliances of every-day usefulness, and there stand to his credit two major inventions. But in his later years, whether through the dimming of his intellect or whether through the pleasure of helping younger inventors to succeed, this old inventor devotes most of his time to the making of models of devices designed by other men. Often, it is true, a "design" that is brought to him is better termed a hope or a vague desire. But he listens in his kindly way, offers a practical hint, and shortly he is given a commission to "go ahead with the model."

I have been both a customer of his and an interested observer of his customers. I pronounce him a genius not only at mechanical invention but at inspiring enthusiasm in the young inventors who come to him for help. Were there a university where inventing were taught as a profession, and had I the power to do so, I should nominate this man as a fit candidate for a professorship.

Inventing, however, is not yet regarded as a teachable art. I am persuaded that it is teachable. Surely it is inspirable—and what is good teaching if it be not the act of inspiring action?

Bachelor of Invention may be a degree that will eventually find place with others now obtainable by the studiously inclined. For the present one must go to such shops as the one in Rochester and write one's thesis in brass or iron, listen to lectures from a "model maker," and receive one's parchment from the patent office.

If the teaching of the art of inventing still seems chimerical, much more so will appear the suggestion that inventors can be invented. An invention, perhaps I should have said before, is a new combination of previously known "elements." A discovery is the finding of a new "element." By "element" I mean any energy-group or thing that is susceptible of combining with or acting with other "elements" to produce a new complex. Electric energy is an "element." The combination of electric energy and a wire wound around a core of iron produces the invention of an electro-magnet.

If, then, an invention consists in combining energy-groups or "elements" so as to effect new results, I conceive that it is possible to invent an inventor. What, indeed, is an inventor if not a complex combination of nerve-cells capable of conceiving new combinations of things? An inventor is a rare combination, you will say, and so he is—at least so he has been—for it is not every day that a good inventor is born. But although nature rarely yields a great inventor, man is capable of outdoing nature, so to speak. A great inventor can be invented—not only can be but has been. In fact there are already several—perhaps a score or more—"artificial" inventors busily at work now. I give herewith a photograph of one of these new creatures, and I call him a composite genius.

The composite genius shown in this photograph consists of 25 Bell telephone engineers to whose combined effort the world is indebted for a most remarkable achievement —the transmission of the human voice across the North American continent. The American Telephone and Telegraph Co., having decided that it would master a problem that had baffled the inventors of Europe, put into the hands of a group of its brightest engineers the task of finding a commercially practicable way of talking from New York to San Francisco. What no one of these men could have accomplished singly, save perhaps in a whole lifetime, was wrought into reality in a few years. Before the close of the San Francisco Panama Exposition, a year ago, hundreds of guests of the Bell company had talked across the continent and had heard the replying voice as distinctly as if it were from across the street.

To me, knowing as I did that this was the achievement of a group of minds working in concert, the miracle of transcontinental telephony—great though it was—seemed overshadowed by an even greater miracle. I saw here a new order of being, a superman, an inventor invented, a composite genius. True, I had heard of such a creature before. I had even seen parts of him, but I had never before seen all of him. I knew that the General Electric Co., for example, had produced the composite genius that had invented first the tungsten lamp and later the remarkable nitrogen-filled lamp. I knew that a German corporation had produced the composite genius that had invented the process of producing synthetic rubber. These, and some other specimens of this new species of superman, I had heard of, but had not seen. At last I had seen one, and I was impressed.

E. H. Colpitts
C. H. Arnold
S. H. Browne
C. A. Robinson
F. B. Jewett
F. B. Driscoll
K. W. Waterson
L. F. Morehouse
E. F. Sherwood
B. Gherardi
J. J. Carty
G. K. Thompson
G. A. Campbell
R. F. Esterbrook
W. L. Richards
J. A. Barrett
C. E. Scribner
O. B. Blackwell
F. L. Rhodes
T. Shaw—Top
H. S. Osborne—Lower
J. L. McQuarrie
H. S. Warren
W. E. Farnham
E. P. Valentine

The Composite Genius That Made Transcontinental Telephony Possible.

A generalization began to take shape and finally I gave it this form: By the co-ordinated efforts of a group of trained minds, any problem in creative reasoning may be solved as effectively as by a single transcendent genius, and with greater speed. The transcendent genius is a brain endowed with keen perception, great persistence, and lively power in co-ordinating known facts. Although few transcendent geniuses are born, a relatively great number can be "made," or formed by a composition of separate minds acting in unison under the direction of a leader.

There is, it will be said, nothing very novel in this conception. But the reply is: Have you, as a manager, been accustomed to attack each new problem by co-ordinating several minds upon it? If not, then the generalization above given is either new to you or it has lacked your full credence. The truth is that relatively few managers attack new problems by summoning a group of men to their assistance. Usually a new problem is handled either by the manager alone or by some one man to whom it is assigned. Co-operative effort in military and naval planning is not new, although in warfare the necessity of quick decision has always tended to make a "board of strategy" somewhat inefficient. In commercial and industrial life there have long existed boards of business strategists, and perhaps most of the phenomenal successes of our Rockefellers and Carnegies are attributable to their solving business problems through the aid of groups of skilled assistants who work together on each new problem. Be this as it may, the mechanical and chemical inventor has, until very recently, been a monad, a single-cell creature, working usually for himself, by himself. Have we not come to a new era of invention, when to the composite genius will come most of the great successes? Is not Edison himself, working in his laboratory at the head of scores of assistants, a type of the composite genius? Are not most of the Edison inventions the work of many men rather than of the one man, Edison, to whom the patents are granted?

Let me close with this suggestion: If there is merit in the composite genius method of attacking great problems, there must be merit in the composite man method of solving small problems. Because your problems are such that you can not afford to employ a number of high salaried men to solve them, do not go to the extreme of attempting to solve them by a one-brain power machine. Have several men work upon every new problem, even if each gives only a fraction of his time to it, and even if some of the men are not experts in the given work to which the problem relates. Often the best suggestions for improvements in a given line come from men who have had little experience in that line.

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## A SYSTEM OF RECORDING TESTS OF MATERIALS.

Many tests of materials are started in the various navy yards from which definite results are never obtained, either because no record of the circumstances of the tests are made or because the tests are forgotten, due to changes of personnel. In order to make tests of material of more value and to get comparative results from tests of similar materials, a card system was instituted in the New York Navy Yard in 1912. The essential features of this system are described as follows by Civil Engineer Walter H. Allen, U. S. Navy, in the September issue of Public Works of the Navy:

For each test there is prepared a record card 5 by 8 in. This card shows on the face the class of material, the test number, the manufacturer and other data, the formula or specification, the conditions under which the test was conducted, the date of test, and the dates on which periodic inspections are to be made. The reverse side of the card is reserved for final opinion at the conclusion of the test. These record cards are filed under headings for class of material. When the original record card is made out, an inspection card is also prepared and filed in a "tickler" for the month in which the first inspection is to be made. The inspection card shows the class of material, the test number, the date of test, and those interested in the test. The remainder of the card is for written report of the inspection. In order to insure that the next test will be made, the inspection card has on it the question, "Has the next inspection card been made out and filed in the tickler," and the clerk in charge of the material test file must make out the next inspection card and place it in the "tickler" before filing the record card and the report of inspection.

When an inspection becomes due, the record and inspection cards are sent to the inspector, who, after making his inspection, returns them via the parties interested to the file clerk.

# AN OFFICE RECORD SYSTEM FOR CIVIL ENGINEERS.

Contributed by J. L. Parsons, Civil Engineer, Humboldt, Iowa.

In the prosecution of all business enterprises the office system is of primary importance as business success is dependent upon economical management and such management must be based upon correlated and analytical records of all phases of the business. Just as truly, an engineer's success depends upon his intelligent grasp of the same fundamentals. This principle is well recognized by the large contracting and engineering companies and much has been published concerning office systems applicable to their needs. In the smaller engineering offices there is a less marked tendency towards office efficiency as engineers thus engaged are more busied with the prosecution of field work and are also more able to maintain a memory grasp of all details. The author believes that every engineer, even though an assistant, should commence the study and development of some system of recording, indexing and filing all data connected with his chosen branch of engineering. This article is intended in a measure to awaken more interest along these lines, by reciting the methods adopted in the author's office and the reasons for their adoption.

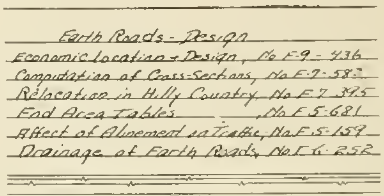
For convenience the subject will be subdivided as follows: (1) The indexing and filing of engineering literature, (2) the indexing and filing of drainage surveys, (3) the indexing and filing of road and bridge surveys, (4) road and bridge cost records and (5) correspondence filing.

(1) **The Filing and Indexing of Engineering Literature.**—All periodicals, pamphlets, society reports, catalogs, etc., which are received are filed systematically, but only information pertaining to the definite lines of engineering practiced are indexed as it was considered an unprofitable use of time to index all subjects. To facilitate their use for reference purposes the pamphlets are sorted according to size and filed under distinguishing letters as soon as received. The standard engineering periodicals which are received are bound by a local printer in heavy manilla-board covers and these are also filed under a distinguishing letter. In this office the following alphabetical-numerical arrangement is used: All pamphlets approximating a 9x11-in. size are placed in a separate pile in a sectional book-case and numbered consecutively under the letter A, as A1, A2, etc. Pamphlets approximating a 6x9-in. size are similarly filed under B, those approximating a 5x9-in. size under C and those approximating a 4x9-in. size under D. The annual reports of State Engineering Societies of which a large number have been collected through the exchange plan followed by the State Engineering Societies are filed vertically in the same manner under the letter E and all bound volumes of engineering periodicals under the letter F. This subdivision has served the needs of this office satisfactorily, but is capable of expansion to meet the demands of sizes and facilities for filing of a larger office or business. As yet the pamphlets filed under A, B, C, and D have been arranged in piles in a set of sectional shelves. This plan has proved objectionable in that the piles soon become so bulky as to render difficult the removal of any desired pamphlet. A set of insert shelving is being planned which will permit the filing of a more limited number of pamphlets on each shelf thus rendering them more readily accessible. No attempt has been made to file and index engineering books in as systematic a manner as the subjects treated by them are usually more specific than in reports, catalogs, periodicals and pamphlets and can be more readily investigated by reference to the titles, tables of contents and indexes.

By the use of this system of lettering and numbering the filing is readily and methodically accomplished and the indexing greatly simplified. Thus if it is desired to index an article on Earth Road Drainage from "Engineering and Contracting" it is only necessary to enter the letter, number and page number on the index card, as, F-22-726 instead of the more complicated reference of Eng. & Contr. Vol. 40, p. 726.

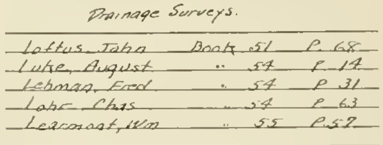
Only three indexing divisions have been used thus far; catalogs, roads and drainage. The indexing is done on standard 3x5-in. cards which are filed behind ⅓ cut dividers, the separators being properly labeled to indicate the subject subdivisions. These cards are filed in the proper-sized drawers of a standard make cabinet which has been added to the office equipment to facilitate the indexing work. The extent to which indexing has been carried did not seem to justify the use of the Dewey decimal system and all matter has been indexed under subject-heads in the manner referred to. Among the subject-heads under catalogs are: drain tile and sewer pipe, trenching machinery, concrete materials, road building machinery, office supplies, etc., etc. Similarly all matter concerning roads and drainage has been indexed under a sufficient number of subdivisions to render the investigation of the literature on any particular phase of the work comparatively simple. Fig. 1 illustrates the extent to which information is indexed.

Although the greater number of the periodicals and pamphlets received are thus cared for a considerable number of data are available in publications not directly related to the lines of engineering practiced. Information of this kind is clipped and filed in folders with projecting tabs on which the subject-heads are indicated as in the case of the dividers for the index cards. These folders are filed under the general divisions of catalogs, roads and drainage in a letter-size cabinet drawer section. Such folders may also be readily filed in paste-board filing boxes similar to the Macey AL6.



Earth Roads - Design
Economic Location + Design, No F-9-436
Computation of Cross-Sections, No F-7-583
Relocation in Hilly Country, No F-7-375
End Area Tables, No F-5-681
Affect of Alinement on Traffic, No F-5-159
Drainage of Earth Roads, No F-6-252

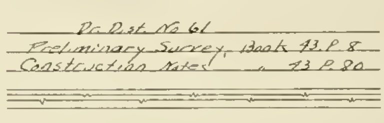
Fig 1



Drainage Surveys.

| | | |
|---|---|---|
| Loftus, John | Book 51 | P. 68 |
| Luke, August | " 54 | P. 14 |
| Lehman, Fred | " 54 | P 31 |
| Lohr, Chas | " 54 | P 63 |
| Learmont, Wm | " 55 | P 57 |

Fig 2

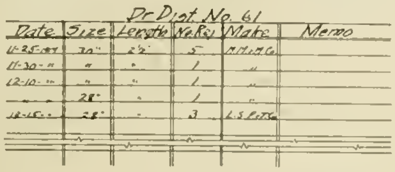


Dr. Dist. No 61
Preliminary Survey, Book 43 P 8
Construction Notes " 43 P 80

Fig 3.

By the consistent application of the foregoing filing and indexing system a large number of valuable data may be rendered readily accessible. But it has been found that engineering data in daily use by an office engineer could be made more convenient for reference by the use of an engineering data book. For this purpose a loose-leaf ring book was utilized. All tables, diagrams, formulas and general data in constant use are filed in this book by copying them on filler sheets, inserting them as sheets or clipping them and pasting them on blank sheets. Some of the tables in most constant use have been copied on tracing cloth and blue-print copies inserted in this book. The data thus entered is divided under the heads of roads and drainage by manilla dividers with projecting tabs, these subjects being further subdivided by similar separators. This data book has proven probably the most convenient book in the office as the most pertinent information is collected under one cover where it is convenient for use and may be readily carried on trips when desired. In this connection the author wishes to emphasize the importance of indexing and filing on loose-leaves and cards instead of in bound books. By the use of the loose-leaf and card system data may readily be added as acquired in a consecutive manner, and any engineer who has used bound books for the purpose will appreciate the difficulties of estimating the proper space to be reserved for future entries and of continually referring to advanced pages.

(2) **Indexing and Filing of Drainage Surveys.**—The preliminary and construction field notes for both private and drainage district surveys are recorded in the usual bound level books. These books are numbered consecutively, the pages of each book being similarly numbered, and are filed in numerical order in a sectional shelf, the book numbers being placed on the backs of the books for convenience. The notes are then indexed by district numbers or by names of employers under alphabetical and numerical indexes. Fig. 2 is a sample index card for private surveys and Fig. 3 for drainage district surveys. The index cards for private surveys are filed under an alphabetical set of dividers and those for drainage districts may be filed by the use of ⅓ cut dividers on which are entered the numbers or names of the districts as the case may be. In cases of districts containing a number of separate units the note books are also indexed in the front pages for the convenient location of the notes concerning any particular phase of the work. After several years' use of field note books the bound books have been found preferable to the loose-leaf. The books being substantially bound there is little danger of loss of pages by misplacing or being torn out and blown away on windy days in the prosecution of field work. By the use of the index cards any desired notes are readily located in the bound books even though the notes for one project be included in several books.

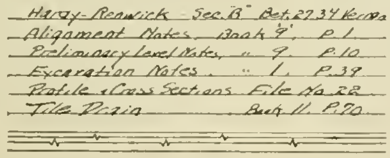


Dr Dist. No. 61

| Date | Size | Length | No. Rej. | Make | Memo |
|---|---|---|---|---|---|
| 11-25-'14 | 30" | 2½' | 5 | M.M.T.Co. | |
| 11-30-" | " | " | 1 | " | |
| 12-10-" | " | " | 1 | " | |
| " " | 28" | " | 1 | " | |
| 12-15-" | 28" | " | 3 | L.S.P.T.Co. | |

Fig. 4.

In the filing of plats, profiles, blue prints, assessment rolls, estimates and reports the following plan has been found the most practicable. For the purpose of filing tracings and blue prints of plats and profiles folders are used which are cut from a roll of the toughest manilla paper that could be purchased. This paper is cut to a 36x55 in. in size and folded to a 28x36 in. in size thus leaving one fold projecting 1 in. on which projection the names or numbers of the districts contained in the folder are entered. The folder is used instead of plain dividing sheets in order effectually to confine the plans. This plan of filing tracings flat is preferable to filing them in tubes as they are maintained in the proper position for convenient blue-printing. Each folder may contain the plans for one or more projects depending upon the extent of the plans. If more than one project is filed in one folder plain manilla sheets are used as dividers. The best plan of filing these folders is to file them in shallow drawer cabinets containing approximately five folders to the drawer. The plans for each project could be given consecutive file numbers and indexed by file numbers, but the districts being numbered consecutively in this locality it has not been found necessary to use other than district numbers for filing purposes.



Hardy-Renwick Sec. "B" Bet. 27-34 Renwa
Alignment Notes, Book "9", P. 1
Preliminary Level Notes, " 9 P. 10
Excavation Notes " 1 P. 39
Profile & Cross Sections File No. 22
Tile Drain Book 11 P. 70

Fig. 5.

Typewritten reports and assessment rolls for each district are placed in an open end envelope and filed in a vertical cabinet section, the envelopes being arranged in numerical order of districts. A convenient plan of filing the sets of blue prints of districts under construction is in envelopes in a similar manner thus allowing of the carrying of the envelopes in the pocket during field work. Special books are kept for the monthly estimates in which carbon copies of all estimates are preserved. Upon the completion of each district these copies are removed and transferred to the envelope containing the remaining records.

Because of the conditions under which tile generally are sold by the tile companies it is desirable that the engineer keep a record of the number, size and kind of tile that are rejected by the engineer during construction. Fig. 4 illustrates the method followed in recording these data. Instead of indexing these data in field books it has been found more convenient to transfer it to these 4x6-in. cards, the cards for the different districts being located by ⅓ cut dividers. In addition to the above records another loose-leaf book is kept called the Drainage Record book. The character of the information transferred to this book together with other matter relative to drainage work is explained in detail in the author's book, "Land Drainage," but in general all important information, preliminary estimates, tables of material required, contract prices, names of contractors, dates of commencement of work, dates of completion of work, description of construction difficulties and methods, kinds of machinery used, and later data on the success or failure of the project are recorded in this book in concise form. This book has more than justified the labor involved by its convenience for continual reference during construction and for reference in the design of new projects.

OFFICE OF
HUMBOLDT COUNTY HIGHWAY ENGINEER.
BRIDGE RECORD.
FIELD NOTES.

Humboldt County. Bridge No. *137-W.* Office File No. ........
Field Book No. *L. Leaf* Page No. *17* Date *Apr. 22, 1914*
Location *2 rds. So. Sec. Cor.* Township *Weaver* Section *35-36*
Drainage area *240 A.*
Distance from shipping point *3 mi.*
Distance from concrete materials ..........................

OLD BRIDGE

Span .................. Type *7'x2.5' wood pile*
..............................................................
Distance from top of grade to creek bed *2.E'*
Distance from creek bed to solid foundation ..................
New grade to be *.5* feet above old grade
Foundation material *stiff clay*
High water mark .................. Elevation ...........
Bench mark ....................................................
..............................................................
Present condition *unsafe*
Date repaired ................................................
Kind of repairs ..............................................
..............................................................
Remarks: .....................................................
..............................................................

NEW BRIDGE

Span ........... Width of roadway ........................
Length of wings ..............................................
Type of bridge *3'x3'x30' concrete box*
Date built *1914*
Date repaired ................................................
..............................................................
Kind of repairs ..............................................
..............................................................
Remarks: .....................................................
..............................................................

*J. L. Parsons,*
Engineer.

Fig. 6.

(3) **Indexing and Filing of Road Surveys.**—The field notes for road surveys are taken in standard bound level books as in drainage work. In general these notes include alignment notes, cross-section notes, tile drain notes, and construction notes. All the notes for any particular section of road are kept on consecutive pages of the same note book if possible and in case all the notes are not completed at one time the number of pages necessary is estimated and left blank. However, because of the system of indexing used, no great inconvenience results from including the notes in two or more books. Standard cross-section books are also used in which are listed the essential features of the design of the grade line of a road, as: elevations of surface and grade lines, depth of cut or height of fill, distances from center line to toe of fill or edge of cut, depths of cut from edge of cut to bottoms of ditches or heights of fills from toes of fills to edges of shoulders, cubic yards cut and fill for each 100 ft. section, etc. The preliminary notes have been taken with such

accuracy that the slope stakes have been successfully set directly from these notes. All of the note books referred to are numbered consecutively and filed in numerical order in a sectional shelf case.

The profile and cross-section sheets for each section of road are fastened together with a paper staple and filed in a manilla folder similar to those used in drainage work. A file number is assigned to each section of road, this number being printed on each sheet of the plans for identification. The plans for five sections are filed in each folder and the file numbers entered on the projecting edges of the folders. The folders are then filed in shallow cabinet drawers in numerical order of filing numbers. The indexing of the note-books and plans is readily accomplished by assigning a 3x5-in. card to each section of road on which all data concerning that section is indexed by book number, page number and file number. Fig. 5 is a sample index card. Since the various county roads are given distinguishing names, as the Humboldt-Gilmore City Road, and the road sections are lettered in alphabetical order it is a simple matter to arrange the index cards for a given road in alphabetical order behind a separator on which is entered the name of the road. By the use of this system it requires only a moment of time to locate the desired notes or plans for any section of road.

In the line of bridge work the county engineer is required by the Iowa law under the supervision of the Highway Commission to design all bridges and keep a complete record of all new bridges constructed and of all repairs made on old bridges. An effort has been made to systematize this work in order to escape a chaos of data which would be both unsatisfactory and unduly expensive. As it was impossible because of local restrictions to complete a set of bridge records and a bridge map for the entire county in a reasonably short time whereby bridges could be assigned consecutive numbers the following plan was adopted. A loose-leaf book was carried constantly in the prosecution of all field work and as opportunity offered the field notes for bridges and culverts in that particular section of the county were taken. By this use of the odds and ends of time together with the notes taken in the actual survey of roads the notes for 1020 bridges and culverts were taken in one season. Notes were taken in all cases whether the existing structure consisted of concrete, steel, wood or corrugated pipe in order that the future disposition of the structure could be intelligently considered in the office without additional trips being required. After the taking of the field notes they were transferred to an office sheet, Fig. 6 and each bridge was given a number, the bridges being numbered consecutively as recorded. To avoid delay in the locating of a particular bridge each bridge was also given a letter corresponding to the beginning letter of the name of the township in which the bridge was situated. These records were then filed in loose-leaf covers, 150 sheets being conveniently included in each cover. Small scale tracings of the townships were made to a scale of 2 in. per mile for a bridge map to which the bridges were transferred by inking in the bridge legend in the proper locations and printing in the numbers of the bridges opposite the legend. The following legend is suggested: Wooden bridges and other temporary structures— , all steel bridges— , and concrete-steel and concrete bridges—

On these plats are also designated the county roads, their names and distinguishing letters. Blue prints of these plats have proven very convenient not only in the work of the county engineer, but also to contractors and workmen engaged in the construction and repair of roads and bridges.

The bridge plats being too small to permit the designation of topographical features and as it was undesirable to increase their size or to complicate them with a confusion of data because of their varied use a set of larger scale township plats were made on tracing cloth to a scale of 4 in. per mile to be used as topographical maps. The scale distance between road lines was exaggerated because of the extensive road data that would be eventually included. The purposes to be served by these plats largely governed the information that was shown. Since the drainage area is primarily essential in the design of bridges, all known drainage area divides were indicated. As the county has been largely included in drainage district organizations the transference of the divide lines affecting the roads from the county drainage district plats closely determined the drainage areas for the greater portion of the bridges in the county. Divides not thus determined are taken as needed and indicated on the plat. Since the presence of open ditches and tile lines should be known in many cases to facilitate and render more intelligent the design of road tile lines and the installation of inlets to replace small culverts and care for surface waters these open and closed drains are also indicated on the topographical maps, the sizes of the tile at all road crossings being indicated. All the past records of private and consent drainage district work were investigated and those drains affecting roads were similarly indicated. Inlets are indicated on the plats by small circles. Later it is hoped that the entire county may be connected with a sea-level bench mark by a system of sub-bench marks and the elevations of all the districts in the county connected to this system and be thus reduced to a common datum. When this is done and the greater portion of the county roads are surveyed a fairly complete set of contour lines may be added which will greatly aid in studying the discharge of the different drainage areas and consequently in determining the sizes of bridges, open ditches and tile lines. It is here suggested that if the different counties of Iowa and other states would co-operate in a work of this kind valuable engineering data could be thus accumulated with little added expense. As in the case of the bridge maps the county roads were indicated, but as yet the bridges have not been shown as these plats are considered as exclusively for topographical purposes. Another use has been considered for them, but not put in use as yet, that of using a set of blue or black line prints on a white background of linen as a construction progress map. Water colors could be utilized to indicate the completion of the shaping of the roads, completion of grading to a finished grade line and cross-section, completion of graveling, etc.

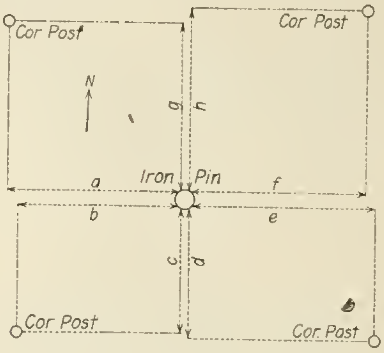
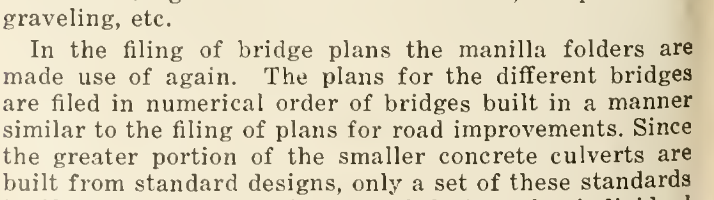


Fig. 7.



Subdivision Carners in Grove Township 92-28

| No | Location | Descript'n | Date | a | b | c | d | e | f | g | h | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | Cen. Sec 34 | Stone | 1914 | | | | | | | | | |
| 29 | 80 R.N.Cen34 | Iron Pin | 1914 | | | | | | | | | |
| 30 | S.W.Cor. 2 | Iron Pin | 1914 | 50' | | | 33' | 0' | 0' | 29.7' | | Rd.to W.of Sec.Line |
| 31 | S.W.Cor. 1 | Stone | 1914 | | | 33' | 304' | | | 32' | | In line with N.&S. |
| 32 | S. ¼ Cor. 1 | Iron Pin | 1914 | | | 33' | | | | 33' | | " " " (Fences |

Fig. 8.

In the filing of bridge plans the manilla folders are made use of again. The plans for the different bridges are filed in numerical order of bridges built in a manner similar to the filing of plans for road improvements. Since the greater portion of the smaller concrete culverts are built from standard designs, only a set of these standards is filed in these cases instead of designs for individual bridges. For convenience all the square box culvert plans have been filed in one folder. The plans for rectangular boxes and circular culverts are also filed separately in a similar manner.

In the road and bridge work of this county one line of work has been undertaken not directly required of county engineers in this state, this being the preservation and recording of government corners. The Iowa general laws are very lax with respect to land surveys there being no engineers officially designated to make and record them. The only reference to this work in the highway law is a clause fixing a penalty for willfully allowing the removal of corner stones in grading operations. The thorough survey of roads for improvement would naturally require that a search for corners be made, but because of the absence of many of them and the difficulty of finding those still remaining many county engineers have based their surveys on estimated locations only. It needs little argument in these days of growing land values to prove the contention that a systematic preservation of corners is of great importance. So in our work in this county an attempt has been made in a measure to care for this neglected work as an auxiliary to the highway and bridge work. In all cases where it was necessary to locate the center line of a road in the survey of a road or the location of a new bridge, a thorough search was made for any stones, stakes or other material that had been used to preserve the section and quarter section corners. If successful in finding some satisfactory evidence iron pins, 2 ft. long and 1 in. square were driven beside or under the stake or stone found. Iron pins were used as the time and means for placing concrete markers was not available and it was believed that the pins would not be subject to removal as readily as the markers used in the past and when relocated their purpose would be more certain than would field stones of more common natural occurrence. In order that the corners thus marked might be readily found in the future without unnecessary searching a complete set of measurements to existing farm corner posts were taken (Fig. 7). These measurements were transferred to tracing sheets in the office (Fig. 8) in order that blue prints might be made for field use. To further assist in the investigation of desired corners a small scale section line plat of the entire county was made on tracing cloth on which known corners were indicated by solid circles. In addition to the corners found in road and bridge surveys a considerable number were found and recorded in the prosecution of private and drainage district surveys. One resulting benefit of importance was the replacing of old wooden stakes which in a short time would become totally destroyed through decay by permanent markers.

| Claimant | Bill No. | Date | Amount | Kind of Work | Location of Work | Remarks |
|---|---|---|---|---|---|---|
| ....*Dannelv, J. W*.................... | .....*45*..... | ..*Aug. '14*... | ...*$154.70*... | ..*Grading*....... | ..*Hum.-Rut., Sec. "A"*...... | ....*4-man @ 65c per hr*............ |
| ....*Drake, T. B*......................... | .....*47*..... | ..*Aug. '14*... | .....*37.59*... | ..*Blasting Trees*.. | ..*Hum.-Clar., Sec. "D"*...... | |
| ....*Dailey, Geo. W*.................... | .....*50*..... | ..*Ang. '14*... | .....*88.25*... | ..*Grading*....... | ..*Hum.-G. I. Cy., Sec. "E"*.. | ....*@ 50c*....................... |
| | | | | | | |
| | | | | | | |

Fig. 9.

COST RECORD HUMBOLDT COUNTY ROAD..*Humboldt-Rutland*..SEC..*A*..

| Year | Kind of Work. | Cost of Work. | Lineal Feet | Cu. Yds. Cut | Cu. Yds. Fill | Width | Thickness | Size | Contract or Day Labor | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| .*1914*. | ..*Grading with Wheelers*............ | ...*$1639.93*... | ..*5265*.. | ..*8108*.. | ..*7815*.. | | | | | ..*20.2c per cu. yd*............... |
| | | | | | | | | | | |
| | | | | | | | | | | |

Fig. 10.

(4) **Road and Bridge Cost Records.**—As yet in this state because of the newness of the highway law, antagonism of supervisors and employment of county engineers by the supervisors, the county engineer is unable to surround himself with the trained foremen, time-keepers and inspectors necessary to the accumulation of real cost data records. However, with proper attention, it is possible to ascertain unit and total costs with sufficient accuracy to make comparisons between the resulting comparative costs of doing work by different methods. In order that a complete record of all bills paid might be constantly available for reference in the county engineer's office a heavy loose-leaf book was appropriated for use as a bill register to which all bills were transferred in alphabetical order of names of claimants. (Fig. 9.) As the work of the counties becomes more complicated and extensive it will probably be necessary to use more detailed forms, but under present conditions these have served admirably. In order that total and unit costs might be made more accessible than by the bill register summaries of costs and data were made periodically and transferred to summary sheets (Fig. 10) contained in a loose-leaf book similar to the bill-register book, the sheets being arranged in alphabetical order of road sections under tabbed dividers on which were entered the names of the roads.

All bills allowed on bridge work were also included in the bill register and thus far transference of important data; unit costs of concrete and steel, etc., has been made to the bridge record sheets. This plan somewhat crowds the data on these sheets but it did not seem desirable or necessary to start a separate set of records for this purpose.

One result of this system of cost-keeping has been to emphasize the following points: That day labor work is advantageous in that there is less delay in getting work under way and less difficulty in getting the work completed in accordance with the plans. That day labor work is disadvantageous in that cost is excessive in approximately 50 per cent of the cases because of the difficulty of securing efficient foremen who will accomplish economical work. And finally that the contract system is most economical unless the engineer or superintendent is exceptionally capable in training foremen and eliminating the inefficient and is given full power to manage this phase of the work without undue interference by the supervisors.

(5) **Correspondence Filing.**—The ordinary practice of filing correspondence alphabetically in a cabinet drawer is followed in general. Most of the correspondence relative to drainage work is filed in folders, one folder being assigned to each drainage district, and all letters received are filed in the proper folders regardless of alphabetical arrangement. This plan has proven convenient as the total correspondence for a certain project can thus be investigated in a very short time without an extended search of the alphabetical index. A similar plan has been followed in much of the highway and private work. In short, in this phase of the work, as in all other phases of the business an attempt has been made to evolve a simple system whereby any desired data might be located with a minimum expenditure of time both in keeping up the system and in its application.

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**Printing from Carbon Sheets.**—Sheets of carbon paper furnish an excellent medium for tracing magazine cuts. The cut is traced with a sharp pencil. The print made from the carbon paper shows blue lines on a white background, thus making it possible to put in pencil notes. The carbon sheets can be renewed by holding them against a hot surface.

## A RATIONAL THEORY OF PRORATING JOINT OR INDIRECT COSTS.

By Halbert P. Gillette.

Where a plant is used to produce only one class and size of units no question arises as to prorating joint costs, for then the total cost during a given period of time divided by the total number of units produced in that time gives the true and full unit cost, assuming that the depreciation costs, lost time, etc., have been properly equated. But where a plant produces units of different classes or sizes the question of prorating the joint costs often becomes vitally important.

The history of industry furnishes many examples of crippled business, attributable largely to improper methods of prorating joint costs. If one of the joint products is priced at less than is equitable, while another product is priced at more than is equitable, the resulting large demand for the underpriced product may speedily pile up losses, while at the same time the decreased demand for the overpriced product may cut down the profitable sales to a vanishing point.

Another source of loss from inequitable prorating of joint costs is to be found where a "side line" of products is improperly loaded with cost charges and made to appear to be unprofitable. Thus many a "side line" is stifled before it has had a chance to become more than a "side line."

Before a rational theory of prorating joint costs can be developed, the prime objects of cost keeping and cost analysis must be considered. Correct unit costs are desirable for two purposes: (1) To furnish a basis for fixing equitable and profitable unit prices; and (2) to provide accurate criteria by which to judge the economic efficiency of men, machines and methods. Both these objects are attained when joint costs are so prorated that the resulting unit costs may be compared with similar unit costs incurred where no prorating is necessary. Thus a merchant who deals in many kinds of goods should so prorate the joint costs—rent, insurance, delivery, clerical, management, etc.—that he may compare the unit cost of any class of goods with the unit price charged by a competitor who specializes in that particular class of goods. For example, the unit cost of candy sold by a department store should be comparable with the unit price of candy charged by a candy store, or, better still, with the unit cost of candy in a candy store.

If a prorating theory is such as to prevent equitable comparison of unit costs of joint production with unit costs of separate production, then the economic efficiency of joint production can not be gaged by comparison with separate production. Furthermore, equitable unit prices that will attract business and secure adequate profit can not readily be made unless the unit costs of joint production are strictly comparable with those of separate production.

If this is a sound economic premise, it follows that a rational method of prorating joint costs must be one that is based on costs incurred under the most economic production of each class of units by a separate plant for each class.

In this connection it is well to note the significance of the fact that joint costs can not be prorated at all where separate production of each of the units is not possible. Thus, the total joint cost of all the parts of a beef may be known, but the unit cost of each its various marketable parts—sirloin, chuck, liver, etc.—can not be determined. If under such a condition joint costs can not be prorated, it follows that the one condition precedent to prorating joint costs is the ability to secure unit costs of each class of units where no other class of units is produced.

We thus come to this important generalization as to prorating joint costs:

Where several classes of units are produced jointly, the total cost of joint production must be prorated among the several classes in proportion to the cost of producing each class (or its equivalent) by a separate plant designed solely for the economic production of the given number of units of that class.

For convenience of reference I will term this rule the separate plant theory of prorating joint costs, or, briefly, the separate plant theory. Where the by-product cost theory—which will be considered later—is not involved, this separate plant theory is applicable under all conditions, and the application of it will disclose both the true economic efficiency of production and the equitable unit price of each class of products jointly produced.

Joint production of different classes of products is an economic mistake unless the total resulting cost is less than the sum of the costs of producing the products separately or in joint groups of fewer different classes. The saving effected by joint production is to be allocated to the different classes of products. The separate plant theory allocates this saving in proportion to the costs of separate production. Were two independent manufacturers of different products intending to join forces, and were these manufacturers making the same percentage of profit on the cost of their products, it is evident that each would regard it as fair to accept his share of the increased profit resulting from the consolidation in proportion to his total original cost of production. Similarly if a company whose sole business was furnishing electric power to a street railway were to consolidate with a company whose sole business was furnishing electricity for street lighting, the resulting saving in the cost of generating current in a joint power plant would be equitably allotted to each company in proportion to its independent cost of generating current, the only proviso being that each company had an economic generating plant. Since, under such conditions, the investment in each of the two separate generating plants would be roughly proportional to their respective peak loads, it follows that an approximation to the separate plant theory is had when the first cost of a joint generating plant is prorated to the different classes of electric service in proportion to the separate peak load of each class. The peak load theory of prorating investment is therefore justifiable only when it conforms in its results rather closely to the results obtained by application of the separate plant theory.

While generating plant investment is a function of peak loads, fuel expense is a function of the amount of current generated, as well as of certain other factors such as the shape of the load curve. But all these varying factors are given their proper recognition in prorating joint fuel expense when the separate plant theory is applied. Likewise every other operating expense is properly prorated on the separate plant theory. When this fact is clearly perceived, a key is had to the solution of all the troublesome prorating problems that confront the person who is trying to ascertain what are equitable rates of charge for electricity or other public utility service furnished to different classes of customers. Indeed the separate plant theory, when fully understood, leads to a proper recognition of the various competitive conditions that are so apt to break down any system of rates of charge based on the ordinary methods of cost analysis.

Turning back to the rule for prorating, above given, it will be seen that the separate plant need not produce precisely the same sort and number of units, provided it produces their equivalent. By this I mean the competitive equivalent or substitute service. To illustrate, assume the existence of a steam railway paralleling a navigable river and handling a heavy freight traffic, but a light passenger traffic. If it were not for the freight traffic an electric trolley line would handle the passenger traffic most economically. Were it not for the passenger traffic, the freight would be most economically hauled in barges. But, by virtue of the combined traffic, the steam railway is more economic than a separate trolley line and a separate barge line. The total annual joint costs of the steam railway are properly prorated to the two classes of traffic—freight and passenger—in proportion to the annual costs by the most economic separate plants, namely, a barge line and a trolley line. The barge line would not give precisely the same sort of service as the steam rail service, but it would give its equivalent—an economic stubstitute service.

One paragraph of digression may perhaps be pardoned. The efforts of railways to eliminate water competition have caused many unfavorable comments, resulting finally in legislation to prohibit such "iniquitous throttling of free competition." Yet a better understanding of the principles of economics may fully justify the elimination of water borne traffic in many places. Certainly if one railway line can handle the combined traffic at a lower cost than the sum of the costs with separate railway and boat lines, it is economic to eliminate water traffic. But when such elimination is effected, equitable rates of charge are to be determined by application of the separate plant theory.

**Average Cost Fallacies.**—Unless the separate plant theory, or some approximation to it, is applied in cost analysis, so-called "average unit costs" are often calculated and used in price making. Yet the "average" may be improperly applied in price making. Thus, the average cost of generating electric current in a central station may be 1 ct. per K. W. H., where the average station load factor is, say, 40 per cent. But to use this 1 ct. cost as a basis for charging residence lighting customers would be economically wrong, even were there no distribution and service costs. Residence customers causing a station load factor of 15 per cent, business customers 22 per cent, and large power customers 60 per cent, may so amalgamate as to cause an average of 40 per cent station load factor; but, as none of the three classes would alone cause a 40 per cent average, none should equitably be charged on the basis of the average 1 ct. generating cost.

While the electrical engineers and managers recognize the importance of such a distinction, the general public often does not. Even keen business men are frequently so ignorant of the principles of correct prorating of costs that they are easily misled by such sophistical arguments as this: "Small shippers of freight are charged the same car load rates as are large shippers. Hence small users of electric current should be charged the same rate as large users—a rate based on the average cost and therefore not discriminatory.

The average cost sophistry is often best exposed by insisting upon the application of average cost to individual cases only where the individual case corresponds with the same average economic conditions.

It has been seriously proposed to estimate all rates of charge for railway freight service of a given class by application of a rule like this: To a fixed cost of blank cents per ton add blank cents per ton-mile.

In estimating the cost of hauling uniform loads by wagon, such a rule is applicable, provided all conditions are the same as those upon which the cost rule is based. But in hauling miscellaneous freight with a railway plant, the prorating of fixed costs upon any general average theory leads to economically absurd results. In a given railway it might be concluded that if the total costs not affected by the length of haul were divided by the total tons of freight, there would be an average cost of, say, $1 per ton. Then the cost of moving the freight might be $^{1}{}_{1}$ ct. per ton-mile. If rates were based on such an aplication of averages in allocating total costs, this absurd result would occur: That it would be cheaper to haul freight 10 miles by motor trucks than by rail. Now, as a matter of fact, precisely that sort of economic absurdity is actually to be found not only in freight rates but in the prices charged for all sorts of products and services. When traced to the cause, the cause will usually be found to be improper prorating of joint costs and the use of so-called "average costs" as a basis for pricing.

**Fallacies in Prorating Proportionally to Direct Costs.**—Almost as prolific in error as the "average cost theory" is the theory of prorating all joint costs in proportion to direct costs. Yet all books on accountancy concur in recommending this method of prorating. There are, it is true, certain joint or indirect elements of cost that are almost direct functions of certain direct costs. Thus the general foreman in charge of several gangs doing different kinds of work is likely to give each gang an amount of his time proportional to the number of men in each gang. So, too, shop rent is closely related to the number of workmen in certain cases, and therefore is properly prorated to the direct cost of labor where wages are relatively uniform. But there are endless conditions under which joint costs are not direct functions of direct costs. Indeed certain joint costs, notably plant interest, may increase as the direct costs decrease. For example, where power is generated hydro-electrically the direct labor costs grow relatively smaller as the investment in the power plant increases. How irrational, then, is it to apportion interest and depreciation charges in proportion to the cost of direct labor in such a plant.

**Estimating Direct Costs by Approximation.**—Direct costs are those directly assignable to a unit or group of similar units of product. If it were possible to keep a record of the time spent by each workman on each class of units, no prorating of labor costs would be necessary except as to the cost of idle or lost time. It is often impracticable to keep continuous time records of each class of work done by each workman. In such cases some simple method of prorating the labor cost is used, and the common mistake is to use too simple a method—one that secures simplicity at the expense of accuracy. Thus joint labor is frequently prorated in proportion to the number of units of material handled, shaped or placed by the laborers.

Prorating labor according to the units of material is often an excellent plan if judiciously carried out. It should involve periodic timing of all the labor processes in relation to the units of material treated by each process. Thus, by minute-hand timing of, say, 5 or 10 per cent of the labor time each month, it is often possible to allocate correctly the entire labor of the month by ascribing certain labor costs to each different class of units of material handled under given conditions. But serious errors may arise if the timing is not carefully done and at regular intervals not too far apart.

Even where the units of material handled are not counted the method of timing labor processes periodically is often an excellent method of approximating the amount of direct labor on each process. The periodic timing method is so inexpensive that it is remarkable how seldom it is applied as a means of approximating direct labor costs.

Where workmen use machines the direct cost both of the labor and the machines is ascertainable in the manner just indicated. In cases where a rather expensive machine is used, it will usually pay to record the length of time the machine is used for each process. Then the direct cost of the machine is readily assignable to each process and only its idle time remains to be prorated. This method is far preferable to prorating machine costs in proportion to direct labor, unless the same labor cost occurs per unit of time in every case that the given machine is used.

Real estate rental can usually be quite accurately prorated according to the floor area assigned to each machine, or to each workman, or to each process. The cost of heat and light is similarly apportionable.

The cost of accounting is usually quite closely related to the number of entries made. Hence by counting the number of entries that each account averages per month, a very close approximation to the direct cost of accounting can be secured.

Once the importance of approximating the direct cost of each process or product is appreciated, comparatively simple yet effective methods of approximation will be devised. By doing so the remaining amount of joint costs will be materially reduced, and thus render any errors of prorating less serious.

**Prorating Non-Productive Time.**—Since neither machines nor workmen are usually worked continuously to full capacity, it often becomes important to determine the cost of non-productive time and to prorate that cost equitably.

Non-productive time is to be allocated in proportion to productive time, but it is usually desirable to record the resulting unit cost of non-productive time separately from the cost of productive time. By doing so attention is focused upon the cost of lost time, and this generally leads to greater effort to increase the "load factor." Furthermore, one of the main causes of wide fluctuations in unit costs from week to week or year to year is the variation in the percentage of idle time. Hence unless the idle time cost is shown separately, there can be no satisfactory comparison of unit costs at different periods.

In case the by-product theory of cost keeping is to be applied, the cost of idle time is not prorated to the by-products.

**The By-Product Theory.**—Hitherto we have considered costs under what may be termed the full cost theory. In order to increase total profits under competitive conditions, it is often necessary to assess against certain by-products only the additional costs of producing them. But a philosophical analysis of the reason for doing so brings us back to our separate plant theory in its broadest form; for if a by-product can not normally be sold at a price in excess of the added cost of producing it with a given plant, then some other separate plant must be producing that class of product at a lower cost than the market price.

**Prorating According to Sales.**—The prorating of joint costs in proportion to the sales of each class of product is at first sight wholly irrational, for it would seem that this is placing effect before cause. Nevertheless this method of prorating is not wholly irrational, and in some cases it is preferable to other methods because it may be a simple way of approximating the separate plant method of prorating. Obviously if a product is sold in a competitive market, the fact indicates that the average unit price over a long period is sufficient to yield a fair profit to some one of the competitors, if not to all of them. Since the competitor who is able to fix the price of a product often is equipped with a plant especially designed to make that product and no other, it follows that other plants that produce the same product plus several other products, are thus automatically forced to adopt the separate plant theory of prorating their joint costs.

**Conclusion.**—The subject under discussion is susceptible of such a diversity of treatment and has so many ramifications that I have been able to touch "the high places" only in this article. I shall have accomplished my object, however, if I have made it clear that one general, underlying theory—the separate plant theory—is applicable in every case, and that all other tenable theories of prorating joint costs are short cut approximations to the general theory.

## COST RECORDS OF DRAFTING AND ENGINEERING.

The knowledge of the cost of drafting and engineering in connection with various projects is of considerable value. Many attempts have been made to keep such records, some with success and some without, but the value of reliable records is generally recognized. A system was installed in the public works department, navy yard, Boston, which has been in successful use for about two years. In devising this system much weight was given to simplicity and ease in keeping the record. The system is described by Civil Engineer R. E. Bakenhus, U. S. Navy, in the September Public Work of the Navy, from which the matter that follows has been taken.

The card system was adopted in such form that the cards could be held on rings in book covers while in use, and could later be filed in drawers or covers. Two principal forms were devised, with two others as extensions. The system may best be illustrated by an actual example of a completed project. The shipbuilding ways at the navy yard, Boston, have been selected as an illustration. This project is known as drafting room job No. 585. Plates I, II, III, IV and V show the cards.

Each employe in the drafting and inspection force is assigned a card for his time record for the month. This card is reproduced as plate No. I. The reverse face of the card is reproduced as plate No. II. Each side of the card contains seven columns or a total of 14, which is found sufficient in actual service. At the head of the column the drafting room job number is placed. The time of the draftsman is entered in money value so that at the end of the month the total on the card must check the pay received by the employe. The advantages of entering money value of the time instead of hours and minutes are

DRAFTING ROOM TIME RECORD, MONTH OF MARCH, 1915.

[Public Works Department, Navy Yard, Boston, Mass.]

Name W. H. W. Pay 5.52

| Job No. | 304 | 305 | 501 | 308 | 585 | 400 | 401 |
|---|---|---|---|---|---|---|---|
| Date 1 | M5.52 | | | | | | |
| 2 | M2.76 | M2.76 | | | | | |
| 3 | M5.52 | | | | | | |
| 4 | | M5.52 | | | | | |
| 5 | | | E2.76 | M2.76 | | | |
| 6 | | | | | SL5.52 | | |
| 7 | | | | | | | |
| 8 | | | | | P5.52 | | |
| 9 | | | | | P5.52 | | |
| 10 | | | | M2.76 | M2.76 | | |
| 11 | | | | M2.76 | P2.76 | | |
| 12 | M1.38 | M1.38 | | | P2.76 | | |
| 13 | M1.38 | M1.38 | | | | | |
| 14 | | | | | | | |
| 15 | | | | M2.76 | P2.76 | | |
| 16 | | | | | P5.52 | | |
| 17 | | | | | P5.52 | | |
| 18 | | | | | S5.52 | | |
| 19 | | | | | S2.76 | | |
| 20 | | | | | | | |
| 21 | | | | | | | |
| 22 | | | | M2.76 | | | |
| 23 | | | | | P2.76 | | |
| 24 | | | | | P2.76 | | |
| 25 | M2.76 | M2.76 | | | | | |
| 26 | M5.52 | | | | | | |
| 27 | | | | M5.52 | | | |
| 28 | | | | | | | |
| 29 | M5.52 | | | | | | |
| 30 | | | | M2.76 | P2.76 | | |
| 31 | | | | | | | |
| Total SL | | | | | 5.52 | | |
| Total P | | | | | 38.64 | | |
| Total S | | | | | 8.28 | | |
| Total I | | | | | | | |
| Total E | | | 2.76 | | | | |
| Total M | 30.36 | 13.80 | | 22.08 | 2.76 | | |
| Grand total | 30.36 | 13.80 | 2.76 | 22.08 | 55.20 | | |

27 ds. at $5.52 = $149.04.

Plate I—Drafting Room Employe's Monthly Record Card Showing Distribution of Time to Jobs.

**Note.**—Under Job No. give daily cost for each branch of work. Use prefix "SL" for Surveys and Layouts, "P" for Plans, "S" for Specifications, "I" for Inspections, "E" for Estimates, and "M" for Miscellaneous.

| Job No. | 313 | 615 | 503 | 536 | 309 | |
|---|---|---|---|---|---|---|
| Date 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | M2.76 | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | P2.76 | | | | |
| 20 | | S5.52 | | | | |
| 21 | | | | | | |
| 22 | | | P2.76 | | | |
| 23 | | | | P2.76 | | |
| 24 | | | | S2.76 | | |
| 25 | | | | | | |
| 26 | | | | | | |
| 27 | | | | | | |
| 28 | | | | | | |
| 29 | | | | | | |
| 30 | | | | | | |
| 31 | | | | | P5.52 | |
| Total SL | | | | | | |
| Total P | | 2.76 | 2.76 | 2.76 | 5.52 | |
| Total S | | 5.52 | | 2.76 | | |
| Total I | | | | | | |
| Total E | | | | | | |
| Total M | 2.76 | | | | | |
| Grand total | 2.76 | 8.28 | 2.76 | 5.52 | 5.52 | 149.04 |

Plate II—Reverse Face of Card Shown in Plate I. Drafting-room Employe's Monthly Record Card (Continued), Showing Distribution of Time to Jobs.

**DRAFTING-ROOM RECORD CARD.**

Job No. 585. Public Works Dept., Navy Yard, Boston. Date issued, Mar. 7, 1914.
Location: Between buildings 103 and 104.
Description of work: Building ways for supply ship.

| | | |
|---|---|---|
| SL Surveys and layouts. | P Plans. | Plans made. |
| Ordered April, 1914 | Ordered March, 1914 | No. 512- 4, May 26, 1914 |
| Assigned to— | Assigned to— | No. 512- 5, May 26, 1914 |
| Phelps | Hammond | No. 512- 6, May 26, 1914 |
| Fabian | Boucher | No. 512- 7, May 26, 1914 |
| | | No. 512- 8, May 26, 1914 |
| | | No. 512- 9, May 26, 1914 |
| | | No. 512-10, May 26, 1914 |
| Completed January, 1916 | Completed May 20, 1914 | No. 512-11, May 26, 1914 |
| | To bureau June [illegible], 1914 | No. 512-12, May 26, 1914 |
| | | No. 512-13, May 26, 1914 |
| | From bureau Aug. 26, 1914 | No. 512-14, May 26, 1914 |
| Total cost .... $351.56 | Total cost .... $1,221.87 | No. 512-20, Sept. 4, 1914 |
| S Specifications. | I Inspections. | References. |
| Begun April 25, 1914 | Contract No. 2108 | Computation book No. 436 |
| Completed April 29, 1914 | Morgan | |
| To bureau July 15, 1914 | Howe | Plans Nos. |
| From bureau October 9, 1914 | Fabian | |
| Printed September 29, 1914 | | |
| Bureau serial No. 2108 | | Letters Nos. File No. 6321 |
| Total cost .... $68.94 | Total cost .... $1,362.09 | |
| E Estimates. | M Miscellaneous. | |
| Hammond | | |
| Total cost .... $97.53 | Total cost .... $26.79 | Date completed, January, 1916 |

Plate III—Drafting-room job record card.

readily apparent. Not the least important feature is that each man is made to realize the actual value of his time and is thus inclined to be more careful of its disposition. As the entry is made it is preceded by a letter designating the character of work done. Particular attention is called to the division of the engineering work into six parts:

First: SL.—Surveys and Layouts.
Second: P.—Plans.
Third: S.—Specifications.
Fourth: I.—Inspections.
Fifth: E.—Estimates.
Sixth: M.—Miscellaneous.

It will be seen how simple it is to carry out the records with these subdivisions.

**SUMMARY OF CHARGES AGAINST JOB ORDER NO. 585.**
Form No. 4, 1914.

| Month. March. | SL. | P. | S. | I. | E. | M. | Total. |
|---|---|---|---|---|---|---|---|
| Adams | ..... | 25.28 | ..... | ..... | ..... | ..... | 25.28 |
| Hammond | ..... | 98.28 | ..... | ..... | ..... | ..... | 98.28 |
| Phelps | ..... | 5.76 | ..... | ..... | ..... | ..... | 5.76 |
| Boucher | ..... | 44 | ..... | ..... | ..... | ..... | 44 |
| Fabian | ..... | 3.28 | ..... | ..... | ..... | ..... | 3.28 |
| Total for month. | ..... | 176.60 | ..... | ..... | ..... | ..... | 176 60 |
| Brought forward | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Grand total.... | ..... | ..... | ..... | ..... | ..... | ..... | 176.60 |
| Month. April. | SL. | P. | S. | I. | E. | M. | Total. |
| Hammond | ..... | 95.76 | 17.64 | ..... | ..... | ..... | 113.40 |
| Phelps | 5.76 | ..... | ..... | ..... | ..... | ..... | 5.76 |
| Boucher | ..... | 92 | ..... | ..... | ..... | ..... | 92 |
| Fabian | ..... | 22.96 | ..... | ..... | ..... | ..... | 22.96 |
| Adams | ..... | 18.96 | ..... | ..... | ..... | ..... | 18.96 |
| Total for month. | 5.76 | 229.68 | 17.64 | ..... | ..... | ..... | 253.08 |
| Brought forward | ..... | 170.60 | ..... | ..... | ..... | ..... | 176.60 |
| Grand total.... | 5.76 | 406.28 | 17.64 | ..... | ..... | ..... | 429.68 |
| Month. May. | SL. | P. | S. | I. | E. | M. | Total. |
| Adams | ..... | 25.28 | 9.48 | ..... | ..... | ..... | 34.76 |
| Hammond | ..... | 60.48 | ..... | ..... | 25.20 | ..... | 85.68 |
| Total for month. | ..... | 85.76 | 9.48 | ..... | 25.20 | ..... | 120.44 |
| Brought forward | 5.76 | 406.28 | 17.64 | ..... | ..... | ..... | 429.68 |
| Grand total.... | 5.76 | 492.04 | 27.12 | ..... | 25.20 | ..... | 550.12 |

Plate IV—Reverse of Card Shown on Plate III. Cost Record of Job No. 585.

At the foot of each column a space is provided for totaling the charges under each subhead for the job, with a grand total. These cards are found to be simple and practical and no modification has suggested itself during the two years of use.

At the end of the month the costs are transferred to the proper column on the individual job cards. The face of the job card is reproduced as plate No. III, and the reverse of the job card as plate No. IV. The face of the card contains the principal data with reference to the job. As a new card is made out it is assigned a job number, which thereafter is used for all drafting-room records. The face of the card contains also the summary of the actual costs of the drafting and engineering work, and on completion of the job this one card contains all the information that is generally desired.

On the reverse of the job card (plate IV) the records from the men's individual cards are entered each month. The forms are devised in such a way that all the original entries are made on the cards; no computations or additions on scraps of paper are necessary. Under each month 10 spaces are provided, which are found sufficient in this department for entering the individual names of the men on any one job for a month. In larger offices more space might be necessary and in smaller offices, less would be sufficient. At the foot of the monthly record each subhead is totaled and at the right of the column

**SUMMARY OF CHARGES AGAINST JOB ORDER NO. 585.**

| Month. March. | SL. | P. | S. | L. | E. | M. | Total. |
|---|---|---|---|---|---|---|---|
| Adams | ..... | 28.44 | ..... | ..... | ..... | ..... | 28.44 |
| Wedlock | 5.52 | 38.61 | 8.28 | ..... | ..... | 2.76 | 55.20 |
| Phelps | 28.80 | 5.76 | ..... | ..... | ..... | ..... | 34.56 |
| Kneeland | ..... | ..... | 4.80 | ..... | ..... | ..... | 4.80 |
| Morgan | ..... | ..... | ..... | 108 | ..... | ..... | 108 |
| Howe | ..... | ..... | ..... | 98 | ..... | ..... | 98 |
| Fabian | ..... | ..... | ..... | 88.56 | ..... | ..... | 88.56 |
| Boucher | ..... | 46 | ..... | 20 | ..... | ..... | 66 |
| Tot'l for month | 34.32 | 118.84 | 13.08 | 314.56 | ..... | 2.76 | 483.56 |
| Bro't forward.. | 118.44 | 955.54 | 47.28 | 324.22 | 66.33 | 21.27 | 1,533.08 |
| Grand total.. | 152.76 | 1,074.38 | 60.36 | 638.78 | 66.33 | 24.03 | 2,016.64 |
| Month, April. | SL. | P. | S. | L. | E. | M. | Total. |
| Adams | ..... | 44.24 | ..... | ..... | ..... | ..... | 44.24 |
| Hammond | ..... | ..... | ..... | 82.53 | ..... | ..... | 82.53 |
| Wedlock | ..... | 5.52 | ..... | 71.76 | ..... | ..... | 77.28 |
| Howe | ..... | ..... | ..... | 24 | ..... | ..... | 24 |
| Phelps | 37.44 | 11.52 | ..... | ..... | ..... | ..... | 48.96 |
| Morgan | ..... | ..... | ..... | 100 | ..... | ..... | 100 |
| Boucher | ..... | ..... | ..... | 100 | ..... | ..... | 100 |
| Fabian | ..... | ..... | ..... | 82 | ..... | ..... | 82 |
| Tot'l for month | 37.44 | 61.28 | ..... | 460.29 | ..... | ..... | 559.01 |
| Bro't forward.. | 152.76 | 1,074.38 | 60.36 | 638.78 | 66.33 | 24.03 | 2,016.64 |
| Grand total.. | 190.20 | 1,135.66 | 60.36 | 1,099.07 | 66.33 | 24.03 | 2,575.65 |
| Month. May. | SL. | P. | S. | L. | E. | M. | Total. |
| Adams | ..... | 12.64 | ..... | ..... | ..... | ..... | 12.64 |
| Hammond | ..... | ..... | ..... | 102.69 | ..... | ..... | 102.69 |
| Wedlock | ..... | 8.28 | ..... | ..... | ..... | 2.76 | 11.04 |
| Phelps | 63.36 | 5.76 | ..... | ..... | ..... | ..... | 69.12 |
| Morgan | ..... | ..... | ..... | 100 | ..... | ..... | 100 |
| Boucher | ..... | ..... | ..... | 66 | ..... | ..... | 66 |
| Fabian | ..... | ..... | ..... | 72.16 | ..... | ..... | 72.16 |
| Tot'l for month | 63.36 | 26.68 | ..... | 340.85 | ..... | 2.76 | 433.65 |
| Bro't forward.. | 190.20 | 1,135.66 | 60.36 | 1,099.07 | 66.33 | 24.03 | 2,575.65 |
| Grand total.. | 253.56 | 1,162.34 | 60.36 | 1,439.92 | 66.33 | 26.79 | 3,009.30 |

Plate V—Continuation of Cost Record of Job No. 585, Showing Entry of Costs for March, April and May, 1915.

the time of each individual is totaled, and again at the foot the grand total is placed. The grand total is carried forward each month so that at the end of any one month the total cost to date for each of the divisions, as well as for the job as a whole, may be seen at a glance.

As the reverse of the card would be insufficient to contain the record for a large job, other cards are printed with the face and reverse sides the same as plate No. IV.

An examination of the plates will show the advantages of the system. However, it is considered well to briefly outline them to make them clearer:

(a) The total cost of plans, specifications, inspections, etc., for each job is given to date at the end of every month.

(b) The completed records form a good basis for estimating the cost of engineering or drafting on smaller jobs.

(c) The records give accurately the cost of inspection on contract work and give as well the distribution of this cost which is of value on contracts that have extended beyond the contract time of completion.

(d) The records give in detail the disposition of the time of each man. This is of value as a part of the man's record.

(e) The system shows each man just how he has been spending his time, and he can determine for himself whether it has been profitably expended or otherwise, and it has thus been an inducement to pay attention to this feature.

Separate standing job numbers are given to certain general drafting room jobs as indicated by the following table:

300—Inspection of piers and waterfront.
301—Inspection and care of tide gage.
303—Inspection of materials for yard use—miscellaneous.
304—Photographic work for public works department.
305—Photographic work for other departments.
306—Blue printing.
308—Miscellaneous, such as filing, time cards, etc.
309—Changes in water, heating mains, compressed air, steam lines, paving, etc.
310—Railroad track system.
311—Compilation of data of various kinds.
312—Soundings and plotting of same.
313—Cement testing.
314—Work (plans, estimates, etc.) connected with annual reports.
315—Naval Hospital, Chelsea, Mass. Emergency repairs to buildings and inspections in accordance with Navy Regulations.
316—Bringing subsurface plans up to date.
317—Editing magazines.
318—Estimating work with estimating section.
319—Testing yard scales.
400—("Maintenance" employes) holiday pay.
401—("Maintenance" employes) annual leave.
402—Holiday pay, hospital, Chelsea.
403—Leave, annual, hospital, Chelsea.

## CITY MANAGEMENT: AN OPPORTUNITY FOR ENGINEERS.

### The City Manager Plan at Jackson, Mich.*

By Gaylord C. Cummin, City Manager.

The Commission-Manager form of City Government is an exact parallel to the form which our experience has taught is the only one under which satisfactory results can be obtained in business. It is not presented as bringing about a municipal millennium. Nor, is it new in principle—only in application. There are no mysterious or wonderworking powers concealed within it. It is simply the application to city government of the only methods by which we have been able to manage business corporations efficiently. It does not insure efficient government. No charter form can do that, but it is the only form under which efficient government can be expected, judging by our experience in business.

It consists briefly of a small council elected at large, corresponding to a board of directors and whose duties are purely legislative. This body appoints the chief administrative officer, the City Manager, who corresponds to the general manager of a corporation, and who has complete control of the whole administrative machinery. He holds office at the pleasure of the Commission and is responsible to it for his acts. Responsibility is absolutely centralized on the Commission and through them on the Manager.

There is never any chance to dodge an issue by placing the blame on somebody else. If anything goes wrong in the administrative branch the Manager can be held responsible and the people can call their representatives to strict account for mistakes and inefficiency in the administrative branch, because of the Commission's power to remove at will the City Manager.

What has been the result of this mode of operation? In the City Manager cities party politics has been entirely eliminated from the administrative side of city affairs. In our city the Commission do not know my politics and I do not know those of a single one of my subordinates, and, furthermore, I do not care. A man's beliefs on the tariff or our Mexican policy have no bearing upon his efficiency as a water works superintendent. What possible difference does it make whether the dog-catcher is a Democrat, Republican or Socialist, providing he is a good dog-catcher?

We have teamwork in our organization and nothing can be accomplished without that. We must have it because the department head that refuses to work in harmony with the manager will soon be looking for another job, and the manager who will not work with his commission will not last very long.

Our department heads are selected for special fitness for the positions which they hold, and not because they are "good fellows." The manager must select on this basis because an inefficient department head will reflect on the manager and he cannot evade his responsibility.

Responsibility is centralized from top to bottom and this is the best incentive to honesty and efficiency that has yet been devised.

Our accomplishments in Jackson after one year's operation are as follows: We have taken city employes out of politics, reorganized the police force, and are developing it on the basis of a survey of its needs made by an expert in police organization; are using a trained social worker as policewoman to handle the young girl problem; have installed a modern system of double accounting with controlling accounts; have passed our annual budget based on a uniform classification of expenditure by kind; have installed careful cost accounting on city construction work, separated the sinking fund from the general fund and put it to work; accumulated a sinking fund balance of $45,000 where the old government had none; centralized the water department under a competent superintendent; read meters quarterly instead of semi-annually; present bills to consumers as does any like public utility.

We have divided the city into three sections, so that the same force of meter readers can be employed constantly, the bills for one section being due each month; have made a waste water survey; and are reinforcing the much neglected distribution system on a rational basis. We make purchases for the city through a purchasing agent and take all cash discounts, these amounting to enough to pay all the expenses of the purchasing agent and his office. We have replaced $380,000 on the tax rolls that was formerly exempt without legal reason; and made all assessments both for taxes and special purposes under one man on full time instead of nine elected assessors on part time, at a saving in cost and increase in efficiency. We are saving $4,000 per year by paying the treasurer a salary instead of fees.

We are making a complete study of the very inadequate sewer system, based on a topographic map now being made on a scale of 1 in. equals 200 ft. and with a 1-ft. contour interval, and are contemplating a complete redesign on modern lines with a comprehensive plan for relief as well as for future extensions. We have installed a modern boulevard lighting system under a peculiarly advantageous contract; installed patrol system of repair on graveled streets; are giving efficient food and milk inspection; have replaced a part-time health officer with a competent physician on full time; made over twice as many inspections with one sanitary inspector as were made formerly by two; have centralized privately supported public nurses, the organized charities of the city, the city poor relief and humane officer under a trained social worker so that there is no duplication of work; we have made the city hospital and training school for nurses a model in so far as the buildings will allow; will construct this year a modern hospital building to cost $150,000; have equipped and opened a tuberculosis hospital; equipped and opened two branch libraries; started the improvements on a new 520-acre park; are motorizing the fire department on a plan that will make it unnecessary to purchase any new horses or sell any horses at the height of their usefulness; are completing a building code; are giving efficient electrical inspection, and have inaugurated inspection of weights and measures.

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*From a paper presented before the Western Society of Civil Engineers.

We have reduced the net debt over $50,000, paid off a floating indebtedness of over $20,000, given over $15,000 services not contemplated and ended the fiscal year with a cash balance of nearly $10,000 and liquid accounts receivable of $37,000, and have not raised the tax rate. Furthermore, although theoretically we operate for six months on borrowed money, and heretofore money was borrowed seven to eight months before receipt of taxes, we are now in our fifth month and have not borrowed a cent.

Any city can get as good results by using a few business methods and a little business sense. I am not detailing these things for any other purpose than to show the possibilities of this mode of operation, and to give a slight idea of the diversity of questions that come before a city manager. I have the administration of such unusual things as a public library, two hospitals, two cemeteries and a small summer resort.

The special point of interest to engineers is that all the larger cities operating under this form of government, have engineers as city managers and they are making good. In fact, in many cases none but engineers are being considered. A city manager must be primarily an executive, but given that qualification the engineer is preferred over men of other professions, because such a a large percentage of the problems which arise are engineering problems.

There are now over 80 cities and towns operating under this plan and the number is just about doubling each year. Where are we to find the city managers for these openings? Most of them will be drawn from the engineering profession direct, for a good many years, but finally we hope that the plan will spread so that a man can take it up as a profession, start as manager of a small town after having received an engineering education, and be promoted to larger ones if he makes good.

In this field there will be in the near future many openings for engineers, well paid permanent positions, where the engineer can at last take his proper place in public service to the lasting benefit of both engineer and citizen.

## The City Manager Plan at Morris, Minn.*

By Sam Siverts, Jr., City Manager.

The progressive and enterprising citizens of Morris believed that the old federal system could be bettered in many respects by a new home rule charter with a commission manager. It was my good fortune and privilege to become the first manager. While there were many problems to meet, there is no small amount of pleasure and satisfaction in feeling that some degree of success has been attained with the aid of the good judgment and patience of as intelligent a commission as one could ever hope to work with.

There was quite a large percentage of the people, especially those who had been more or less intimately connected with the running of the various city functions, who looked upon the working of the new form of government with rather a hostile and skeptical eye. Furthering a close inspection of municipal activities was a part of our mission and it has been encouraged. Constructive criticism is what is needed to stimulate municipal officials to a better and more efficient discharge of their duties.

Getting things down to a business basis, keeping accurate costs of the work done, the making of a full annual report, and the publishing of detailed reports on the various phases of the public work, together with financial statements from time to time, have done a great deal to create the proper amount of satisfaction when something new is tried.

By combining the duties of the clerk, city engineer and water superintendent in the city manager, economy was effected aside from the advantage of having continuous and conscientious oversight by a non-partisan.

Administrative salary expense was reduced the first year from 89 ct. to 49 ct. per capita, the population of the city being considered the same—2,100—both years.

The expense of the police department was decreased without diminishing its efficiency from $1.06 to $0.80 per capita.

The budget for the coming year calls for an increase in the rate of taxation of 1.7 mills more than last year for the support of general running expenses and the contemplated improvements which are as large as last year's. This can be effected, even though the city loses $7,500 in liquor license due to county option, because the balance on hand Jan. 1, 1916, practically $9,300, a balance $6,300 larger than it was two years ago when the change was made, will be sufficient to make up the loss. The appropriation for the sinking fund was increased from $1,000 to $2,500 in effort to redeem in 1918 as many maturing bonds as possible.

An economy of from 15 to 20 per cent has been effected by the city acting as its own contractor in the laying of sewers; water main, where necessary, has been laid in the same trench.

A garbage, refuse and ash collection has done much to improve the looks of the city. Unsightly holes have been filled with the ashes and a vacant block has been drained and filled for the purpose of eventually making a park and playground out of it.

Sentiment has to be aroused and the engineer should take up the idea and push it. Engineering societies should make a definite stand for having as efficient an organization in municipal business as they have in the contracting or industrial plants they control and manage.

Practically all of the present city managers are engineers. It has been objected that for the large city especially the engineer loses his identity as such, while in the smaller town, under 5,000, he usually assumes the duties of city engineer. The objection does not seem to be valid, however, as the business-engineer-manager, in order to intelligently supervise the city's work, is constantly required to pass on purely technical subjects.

## The City Manager Plan at Norwood, Mass.*

By C. A. Bingham, City Manager.

In the straight commission plan there are elected at large five men, each of whom assumes complete control of a division of the government. While this system has brought many cities up out of the former political quagmire, yet it has three weak points. First, often the same body appropriates the money that spends it. Second, the danger of the influential commissioner securing the lion's share of the budget for his pet department. Third, and most important: while a commissioner may be an excellent physician or a skilled barber, yet he is not a road builder nor a sanitary engineer, and he will not be able to secure an engineer with true professional ethics who will countenance his interference. On the other hand, if he secures the reverse kind of an engineer, woe be to efficient public works.

Having passed through these various experiences and probably numerous others, the wide-awake electorate is endeavoring to secure the addition of an official who will act between the board and its departments. In short, one who will run the government on their policies, but through his execution. Unfortunately many people have the wrong conception of his position and his duties; he is not an autocrat, but is a "controlled agent" of the governing board. He does not control the treasurer, auditor or attorney (except unfortunately under a few of the very early charters). These men all check his financial operations. He cannot spend money for any cause whatsoever unless an appropriation has been passed for it in the annual budget by the board or by the voters, as the case may be. As in everything else, the plan will not work itself. Capable business men must be kept on the controlling board, men who are not swerved by private interests, but who will take interest in outlining policies for the advancement of their community; and yet who will not lag into either of the extremes of neglecting affairs entirely or on the other extreme of interfering with petty details.

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*From a paper read before the Minnesota Surveyors' and Engineers' Society.

*From a paper presented at the Newark, N. J., convention of the American Society of Municipal Improvements.

Then, again, care must be used in the selection of the manager. Primarily he should be an engineer with municipal experience. Again the smaller the city the more difficult task he has, for he will be limited in the salaries he can pay his superintendents, thus meaning that he, himself, must do a larger amount of detail work in each department than the manager of a city many times larger where he may be an inside executive entirely, trusting the detail to high priced directors. Unfortunately, some cities have selected as their man the lowest bidder!

Before launching this plan, many preliminaries are necessary which if inaugurated simultaneously would be such an upheaval that failure would surely result.

First, accounting and budgets. No business of whatever nature can long endure prosperity unless it has a thorough and yet simple system of accounting and cost recording, and similarly it must work on a well-defined budget which will insure against the possibility of an overdraft or deficit in any appropriation. This budget and the resulting accountancy must be so devised that it will not only be comparable year by year, but will give details by which efficiency of operation and final accomplishment may be secured.

Second, valuations and tax rate. The assessors should be appointed on fitness by the governing board and not thrown upon the political seas. A re-valuation brought the tax rate of Norwood down from $25.60 per thousand to $12.80. The result is that a $4,000 home formerly assessed at $3,000 and paying $76.80 taxes per year is now assessed at the full value of $4,000 and yet the assessment is only $51.20. On the other hand, a man might have remonstrated at a valuation of $75,000 and now be assessed in the millions. In short, it puts the burden where it belongs.

Third, municipal ownership. This same community operates an electrical plant that not only receives no appropriation from public funds, but donates $15,000 free street lighting per year and builds its white ways and underground conduits out of profits. The water, sewer and cemeteries are also municipally owned, but of course with less profit, although often the earnings of one department are appropriated for some other branch of the government.

The last step is community spirit. Our community centers and allied activities are the finest levelers of citizenship possible. In its forums have been sown the seed of good citizenship which recognizes neither politics nor religion. Can you imagine a community where the contributing of 5 per cent of your salary for the political pot is as unknown as the "slide rule" is to a coal miner?

The writer always shakes a doubting head as to the advisability when he reads a list of the wonderful accomplishments achieved in the first year or two in any community under the manager plan—very often you even fail to find them on the list the following year. But I do know for a fact that even in a municipality under 15,000 population you can work wonders by combining departments, eliminating unnecessary and superannuated fixtures, concentrating authority and converging the operating lines to one head. Costs of construction have been lowered as much as 55 per cent and output increased 300 per cent by simply common sense changes, no efficiency buncombe. Without doubt, the commission manager form is the simplest way of eliminating politics and cliques in fire, police and other departments. As to purchases, any city no matter how small can save many times the expense of running a purchasing department, and enough on cash discounts alone to offset considerable of the clerical force.

### The City Manager Plan in San Jose, Cal.*

By Thomas H. Reed, City Manager.

In San Jose with the exception of the city auditor and police judge, who are elected by the people, and the city clerk, who is appointed by the council, and the civil service commission and city planning commission, each being a little aside from the ordinary cares of administration, the officers are all appointed by the manager, including the members of the board of education and library trustees. The manager may remove any member of the city administration. That is, his power is absolute, so far as the administrative side of the matter is concerned. So long as he is in favor with the council, so long as they respect his judgment, he is in command, and he is responsible for what goes well or what goes ill in the institution.

We have not accomplished wonders yet. I think that every man who undertakes a task of this kind, indeed every man who goes into any munipical office, feels that the first thing that he wants to impress upon the public is that they must wait a reasonable time for results. The public has a peculiar habit of expecting that a reform administration, when it comes into office, is going to succeed in a few weeks in revolutionizing the course of years and years of municipal development. That cannot be done. It is a slow job to reverse the wheels and make them revolve in the opposite direction, smoothly and without friction. We have proceeded slowly in San Jose. We did abolish the office of city treasurer as a paid office, and deposited the funds of the city on one of the banks at 2.52 per cent interest on average daily balances. We saved the city of San Jose about $5,000 a year by that transaction.

We have installed a modern system of purchasing, buying on scientific principles. We have already made reforms which will result in a saving of approximately $1,000 a month merely on supplies that are bought for the city of San Jose. We have reformed some of our departments, for example, the Health Department, in which formerly we had a health officer, a doctor who gave such of his time as he could for a salary of $100 a month. A busy practicing physician of a successful sort is not able to give very much of his time for that compensation. Under those circumstances you can well realize that our health department was inadequate for the needs of a city of 40,000 population. We have now a thoroughly organized public health department, with a full-time deputy health officer, occupying all of his time in the work of the city, and we are putting that department on a basis where it will be able to stand at the front of all the health departments in the state of California.

We wanted to get a man for the health department to take charge of the work, and a lot of our people said "you must take him from San Jose." We said, "No. We will give an examination, an open, competitive examination, for the position of assistant health officer, and we will fill that place with the best man that comes forward to take the examination, irrespective of where he comes from." And Mr. Gray, at that time health officer of Palo Alto, came forward and took the examination, and passed it with 100 per cent, and we appointed him. We feel that we have a prize, a man who is not a physician but a civil and sanitary engineer trained at the University of California, to be a health officer. We have a health department that is moving like a buzz saw now into the bad public health conditions.

We have done a number of other little things. We have secured the services of a firm to install a modern accounting system. When I went down to San Jose, I discovered that it was almost impossible to find out how much the various services in the various departments had cost. No comparative data of an administrative sort, such as are laid upon the desk of the manager of a private corporation for his enlightenment in handling the affairs of his corporation, were to be had. We are going to have just that sort of thing. We are going to have the best and most up-to-date form of accounting that can be secured, and it will be a form of accounting much more similar to that made use of in first-rate private corporations than the usual traditional forms of municipal accounting.

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*From a paper presented Oct. 12 before the League of California Municipalities.

And then there are a lot of other little things that we have done—all kinds of things. A city manager is expected to do almost anything, apparently, from reconciling the marital difficulties of certain people in the population to straightening out the difficulties of saloon keepers. It all comes into the city manager's office, and, as time goes on, there is more of it coming in. We have notified everybody in the city of San Jose to enter their complaints with the manager. We published that he could be reached at San Jose 88, and San Jose 88 wires are hot all day with this, that, and the other thing. We find out quite a lot by it. In the first place, we find out what we should do to satisfy the public, and, in the second place, we find out something of what our various officials are doing in their official capacities.

We have learned some things about the city manager form of government. We have learned something about what its merits are. It has two merits. One is that it demands the careful and intelligent selection of the various officers to fill the various positions. A manager must make good—that is all there is to it. It does not do him any good to play politics because he cannot make good by playing politics. He must make good in his work. In order to make good in his work, he must select the right kind of men for subordinate positions. It means, in other words, that under the manager plan, you get the right personnel in your city government.

Then there is another thing: It means that you have a single head. There is no place in this world for a two-headed man or a five-headed man, outside of a side show. They are interesting as objects of study, and as matter of scientific observation, just like a five-legged calf, but for the purpose of administration, they are bad. When you have a single head, you have the condition under which you can enforce responsibility, and responsibility is the most sobering and correcting influence in government.

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**Paper Sheet Back Sight.**—A convenient back sight can be made by means of a square sheet of white paper. A small hole is punched near one corner while a larger one is placed near the opposite diagonal corner. The paper is placed in a pointed stick which is stuck in the ground at the time the rodman was there. The diagonal corners of the paper form an accurate back sight.

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**Restoring Blueprint Paper.**—Hydrogen peroxide will restore blueprint paper that has "gone bad." The paper is used in customary manner, printing and washing as usual. The hydrogen peroxide is then applied with a small sponge, bringing out the print in detail.

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A plant on a commercial scale will be built by the Department of Agriculture for the conduct of experimental work in the production of potash from kelp, an appropriation of $175,000 for the purpose having been made at the last session of Congress. Two locations are under consideration, one near Santa Barbara, and the other near Long Beach, Cal. The plans call for a plant capable of handling approximately 200 tons of wet kelp per day. Electric power probably will be used for all mechanical operations, while heat for drying and distillation will be furnished by crude petroleum. The equipment will consist of drying kilns, distilling chambers, vats, handling machinery, and the necessary buildings to house this apparatus.

## CONVERSION FACTORS IN COST KEEPING AS AN AID TO MANAGEMENT.

By Halbert P. Gillette.

There are many kinds of work involving a multiplicity of slightly varying conditions affecting the unit cost, and in such cases it may appear almost useless to ascertain the unit cost. Thus, in setting poles some of the cost variables are: Character of digging, topography, depth of hole, length and class of pole, number of poles involved in one job, obstructions such as trees or existing lines of wire, rate of wages, etc. In spite of all these variables it is possible so to determine unit costs of pole setting as to make rational comparisons of the costs on one job with those on another. This can most readily be accomplished by the use of what may be termed conversion factors.

A conversion factor is the ratio of unit cost under an assumed standard condition to unit cost under a given condition that varies from the standard. Thus, the unit cost of digging a pole hole 5 ft. deep and 2 ft. in diameter in loam may be taken as a standard when wages are $2 a day when the men work steadily 8 hours a day at digging holes. Let the resultant average unit cost of digging be 50 ct. under these standard conditions. The first and most obvious conversion factor is one that provides for lost time due to rain or other conditions beyond the control of the workmen, for which their pay is not "docked." If, for example, rain causes a loss of one hour in the day, the resulting $2 wage becomes 28.6 ct. per hour for the 7 hr., as compared with 25 ct. per hour for the standard 8 hr.; hence, the conversion factor for 1 hr. of lost time is $28.6 \div 25 = 1.144$ or 1 1/7.

By timing the number of minutes required to dig the standard size hole in different kinds of soil, conversion factors for soil conditions are derived. Thus the conversion factor for clay of a given sort may be 1.3, for hardpan 2.5, and so on.

In similar manner conversion factors for holes of different sizes and depths are derived by minute-hand timing.

The number of holes involved in one job affects the cost per hole. If there are too few holes to keep the men busy throughout the day without the loss of time moving to another job, the time lost in moving increases the unit cost. Of course it would be possible to group this lost time with time lost because of bad weather, but it is not desirable to do so. **Time lost due to conditions entirely beyond the control of the manager should not be merged with time lost under conditions that are more or less controllable.** Altogether too much maintenance and construction work is done in small jobs far apart, and without adequate provision for rapidly moving the men from one job to another. The job-size conversion factor calls particular attention to large unit cost of small job work, and leads to study of means of reducing the time lost in moving and getting started.

Rates of hourly wages differ in different localities and in the same locality at different times. Also where small gangs of men are moved about over considerable distances, it is frequently necessary either to increase their wage or to pay their board. Some gangs are not paid for holidays; other gangs are. These and similar causes affect the average hourly rate and make close comparisons of unit costs impossible unless wage rate conversion factors are used.

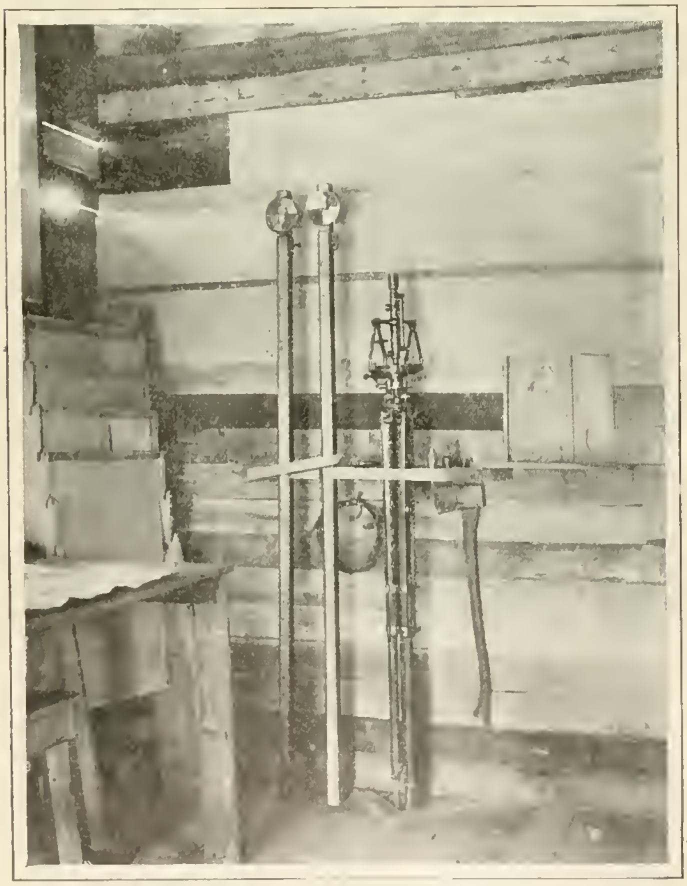
It is rather astonishing how seldom this cost factor is given adequate consideration, particularly when it is so readily determinable. The explanation of remissness on the part of managers in this respect probably is found in their general attitude toward unit costs as criteria of efficiency. Confronted by many variables they are apt to make no attempt to study the effect even of the variables that are readily analyzed. Almost every variable can be rather easily taken into account by the conversion factor method, and none more easily than the wage variable.

In the stringing of wire there are fewer variables of importance than in digging pole holes, yet even these few variables are rarely studied, and almost never used to establish conversion factors. Whether two wires or 12 are strung at one time makes an enormous difference in the cost of stringing per circuit mile. Still, a foreman often speaks with pride of his low unit labor costs of wire stringing, when the true credit for the low cost is assignable not to him but to the large number of circuits put up at the same time. Conversely, short wiring jobs of single circuits strung through trees show seemingly enormous unit costs for labor. By timing the added number of minutes involved in trimming each tree and the delay that it causes in wire stringing, tree-trimming conversion factors are derived, necessitating only on the part of the foreman or timekeeper the recording of the number of trees of a given class to a given number of poles.

Each foreman should be provided with a table of conversion factors and a brief statement of the conditions and number of units that he is to record each day. The ordinary foreman should be required to do little or none of the calculation involved in making the extension where the conversion factors are applied. This should be done in the office with a slide rule. But each foreman should afterward be given daily, weekly or monthly statements of the unit labor costs, reduced by the conversion factors to the common or standard units. Rivalry among different foremen is aroused when periodic statements of unit costs under each foreman are sent out. Even under the existing methods of cost keeping where conversion factors are not used, desirable rivalry is secured by issuing unit cost statements. But the existing method falls far short of what is attainable in this respect by the use of conversion factors. Foremen know that conditions vary to such a degree that the ordinary unit costs (without reduction to a standard unit) are often meaningless.

## INSTRUMENT AND DRAWING RACKS.

A wall rack which does away with the necessity of dismounting a surveying instrument when not in use was employed in the field office of Samuel Austin & Sons Co. on a recent contract. The arrangement is shown in the accompanying illustration. It consists of a shelf with openings to receive the head of the tripod and to take rods. The openings are closed by gates. A useful rack for holding working drawings also is shown on the left in the illustration.



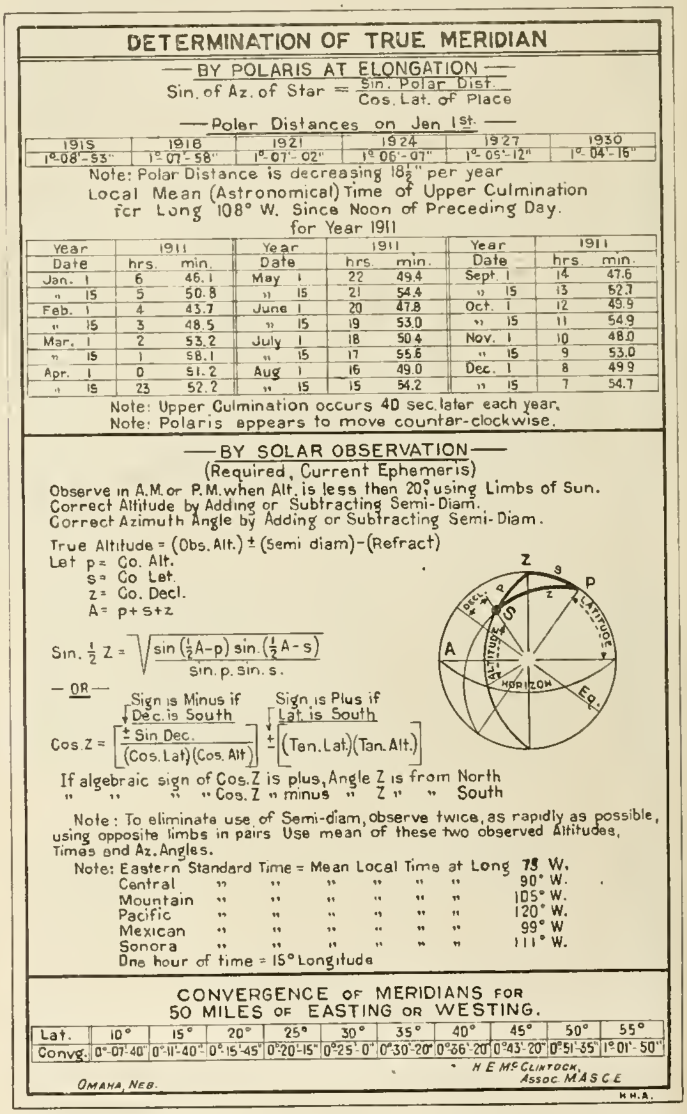
Instrument Rack in Contractor's Field Office.

## FIELD BOOK SHEET FOR DETERMINATION OF TRUE MERIDIAN.

The sheet, reproduced below, was prepared by Mr. H. E. McClintock, assistant engineer, Union Pacific R. R., to show information necessary to determine true meridian. The sheet is of such size that it can be pasted in regular field books, thus permitting this information to be at all times readily available in the field; most field books in use by railroad engineers show nothing of this nature.

The times of upper culmination of Polaris are given for the year 1911 only, with a notation that it occurs 40 seconds later each year, which permits the determination of this time at later dates with sufficient accuracy for the purpose of determining culmination (and elongation).

As it is frequently impossible, because of weather conditions, presence of intervening mountains or other difficulties, or in the lower latitudes, and, of course, south of the Equator, to observe Polaris at elongation, the usual method by solar observation is also included. The necessary corrections and calculations are shown on the lower part of the sheet. Of course the ephemeris for the current year is required, a convenient vest pocket edition of which is supplied gratis by many instrument makers.



DETERMINATION OF TRUE MERIDIAN

—BY POLARIS AT ELONGATION—

$$\text{Sin. of Az. of Star} = \frac{\text{Sin. Polar Dist.}}{\text{Cos. Lat. of Place}}$$

—Polar Distances on Jan 1st—

| 1915 | 1918 | 1921 | 1924 | 1927 | 1930 |
|---|---|---|---|---|---|
| 1°-08'-53" | 1°-07'-58" | 1°-07'-02" | 1°-06'-07" | 1°-05'-12" | 1°-04'-16" |

Note: Polar Distance is decreasing 18½" per year

Local Mean (Astronomical) Time of Upper Culmination
for Long 108° W. Since Noon of Preceding Day.
for Year 1911

| Year | 1911 | | Year | 1911 | | Year | 1911 | |
|---|---|---|---|---|---|---|---|---|
| Date | hrs. | min. | Date | hrs. | min. | Date | hrs. | min. |
| Jan. 1 | 6 | 46.1 | May 1 | 22 | 49.4 | Sept. 1 | 14 | 47.6 |
| " 15 | 5 | 50.8 | " 15 | 21 | 54.4 | " 15 | 13 | 52.7 |
| Feb. 1 | 4 | 43.7 | June 1 | 20 | 47.8 | Oct. 1 | 12 | 49.9 |
| " 15 | 3 | 48.5 | " 15 | 19 | 53.0 | " 15 | 11 | 54.9 |
| Mar. 1 | 2 | 53.2 | July 1 | 18 | 50.4 | Nov. 1 | 10 | 48.0 |
| " 15 | 1 | 58.1 | " 15 | 17 | 55.6 | " 15 | 9 | 53.0 |
| Apr. 1 | 0 | 51.2 | Aug 1 | 16 | 49.0 | Dec. 1 | 8 | 49.9 |
| " 15 | 23 | 52.2 | " 15 | 15 | 54.2 | " 15 | 7 | 54.7 |

Note: Upper Culmination occurs 40 sec. later each year.
Note: Polaris appears to move counter-clockwise.

—BY SOLAR OBSERVATION—
(Required, Current Ephemeris)

Observe in A.M. or P.M. when Alt. is less then 20°, using Limbs of Sun.
Correct Altitude by Adding or Subtracting Semi-Diam.
Correct Azimuth Angle by Adding or Subtracting Semi-Diam.

True Altitude = (Obs. Alt.) ± (Semi diam) − (Refract)

Let p = Co. Alt.
s = Co Lat.
z = Co. Decl.
A = p + s + z

$$\text{Sin.}\ \tfrac{1}{2} Z = \sqrt{\frac{\sin\left(\frac{1}{2}A - p\right)\ \sin.\left(\frac{1}{2}A - s\right)}{\sin.\ p.\ \sin.\ s.}}$$

— OR —

$$\text{Cos. } Z = \left[\frac{\overset{\text{Sign is Minus if Dec. is South}}{\pm}\ \text{Sin Dec.}}{(\text{Cos. Lat})(\text{Cos. Alt})}\right] \overset{\text{Sign is Plus if Lat. is South}}{\pm} \left[(\text{Ten. Lat.})(\text{Tan. Alt.})\right]$$

If algebraic sign of Cos. Z is plus, Angle Z is from North
" " " " Cos. Z " minus " Z " " South

Note: To eliminate use of Semi-diam, observe twice, as rapidly as possible, using opposite limbs in pairs Use mean of these two observed Altitudes, Times and Az. Angles.

Note: Eastern Standard Time = Mean Local Time at Long 75 W.
Central " " " " " " 90° W.
Mountain " " " " " " 105° W.
Pacific " " " " " " 120° W.
Mexican " " " " " " 99° W
Sonora " " " " " " 111° W.
One hour of time = 15° Longitude

CONVERGENCE OF MERIDIANS FOR
50 MILES OF EASTING OR WESTING.

| Lat. | 10° | 15° | 20° | 25° | 30° | 35° | 40° | 45° | 50° | 55° |
|---|---|---|---|---|---|---|---|---|---|---|
| Convg. | 0°-07'-40" | 0°-11'-40" | 0°-15'-45" | 0°-20'-15" | 0°-25'-0" | 0°-30'-20" | 0°-36'-20" | 0°-43'-20" | 0°-51'-35" | 1°-01'-50" |

H E McClintock,
Assoc. M A S C E

Omaha, Neb.

H.H.A.

Field Book Sheet for True Meridian.

Notes showing the meridian at which various kinds of standard time agree with mean local time are shown, thus permitting a direct reduction from Greenwich mean noon to standard time.

The convergence of meridians on any line other than a north and south line amounts to considerable in the higher latitudes, and the last table gives the amount of this convergence for a line of 50 miles in length, thus enabling a ready check on transit work by observation at intervals on a survey.

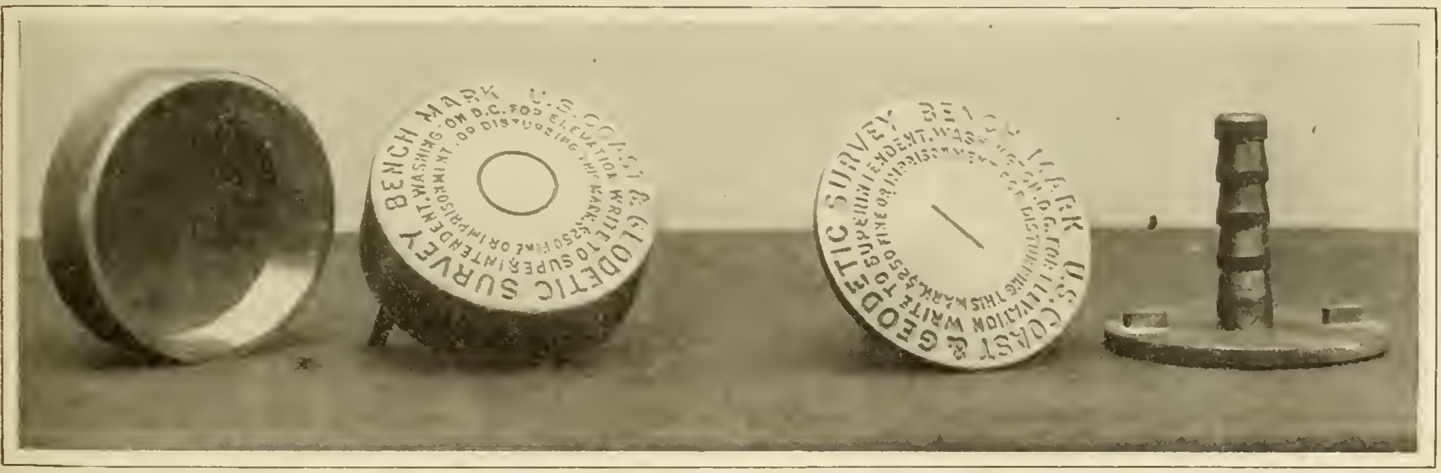
## NAMING AND NUMBERING SURVEYING MONUMENTS OF U. S. COAST AND GEODETIC SURVEY.

The superintendent of the U. S. Coast and Geodetic Survey has recently issued orders to the chief of each surveying vessel and land party to stamp into the face of the metal tablet marking the surveying monuments the name or number of the particular monument. The bench marks established in connection with the determination of the mean sea level by tidal observations and of the elevations in the interior of the country by precise leveling will be marked by tablets properly inscribed on which the number of the bench mark will be stamped. This plan will enable engineers and others to ask for geographic positions or data in regard to the bench marks with the assurance that those at headquarters will know without the least doubt the monuments for which information is wanted.

One of the new tablets used by the survey is shown in the accompanying illustration. These tablets are set in concrete or in masonry structures of various kinds. The name or number of the station or bench mark, respectively, and the date of its establishment are stamped on the blank spaces at the center of the tablet.

The instructions issued to the field parties for marking the stations or bench marks in accordance with the new plan include the following:

Wherever a triangulation, reference, topographic or hydrographic station or a leveling or tidal bench mark is established and marked with the standard inscribed metal disk or cap, the disk or cap should be stamped with the name of the station or the number of the bench mark. There should also be stamped the year in which the station or bench mark is established. If a station or bench mark is recovered which had been marked with an inscribed disk or cap, the name or number and the date when originally established should be stamped. Also, when a recovered station or bench mark, which had not been marked with a disk or cap, is remarked with a disk or cap the name or number and the date of original establishment should be stamped.



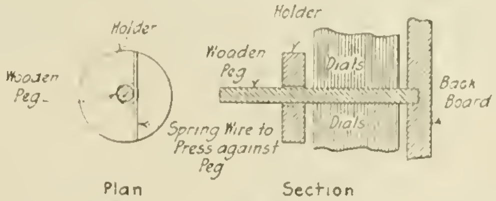
Bench Mark, United States Coast and Geodetic Survey.

When a new or recovered magnetic station is marked with a disk, the year in which the station was established should be stamped on the disk. It is not necessary to stamp the name on the mark of a magnetic station.

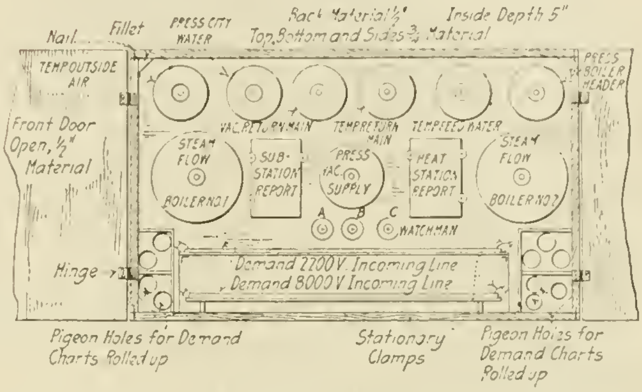
The only exceptions to this general rule should be when the stamping cannot be done except at excessive cost or delay to the work or when to stamp the mark would loosen or destroy it.

## CONVENIENT CABINET FOR FILING CHARTS.

The accompanying sketches, reproduced from the Electrical World, illustrated a convenient cabinet for filing charts. Large, white, distinctive lettering underneath each file of charts indicates clearly and readily the nature of their service. Reports are filed, as shown, with the long rectangular demand charts laid lengthwise on shelves and held in place by suitable stationary clamps attached to each end. The demand charts are eventually rolled up and stored in the pigeonholes.



METHOD OF HOLDING CHARTS ON PEGS



ARRANGEMENT OF CHARTS IN FILING CABINET

The fasteners for charts consisting essentially of wooden spindles with spring holders are constructed as shown in detail. These may be readily purchased, however, in a metal form of better appearance and with a black enamel finish. The cabinet is made of wood 0.5 in. thick, the over-all dimensions being 34 in. by 56 in. by 6 in. in depth. The cover is hinged and provided with a lock. Wooden fillets are used at the inside corners to reinforce the box.

## METHOD OF MAKING STREAM MEASUREMENTS IN WINTER.

Determination of discharge under winter conditions is perhaps one of the most difficult features of stream measurement. The following description the method followed by the Manitoba Hydrometric Survey is taken from a recently issued progress report:

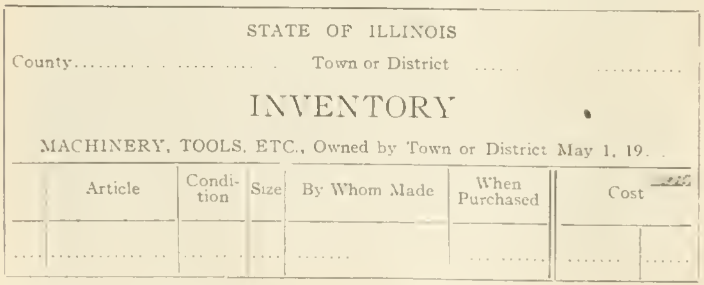
To determine the discharge where an ice sheet is present, holes are cut in the ice at intervals of from 5 to 10 ft., large enough to allow the free introduction of the meter and the measurements are then taken in the same manner as under open-water conditions, except that the depths are computed from the under side of the ice sheet. In addition, the gauge height of the surface of the water, to which the soundings are also referred and the thickness of the ice sheet at the various points across the section are noted. The horizontal distance between these points should preferably be the same as under open-water conditions, although owing to the amount of labor involved in opening up the holes this is not always possible. The meter is either suspended by a cable in the ordinary manner or fastened to the suspension rods; the latter method is generally used where the water is shallow. For depths over 5 ft. the cable is found to be most convenient. In metering under ice conditions, care must be taken to prevent the meter from freezing. In order to obviate this as much as possible, the meter should be kept immersed and the transfer from one hole to another made as quickly as possible, since a small amount of water congealing on the rotor or near the bearing may very materially change the meter's rating. Should the meter become frozen, it may be thawed out by immersing in the water or carefully warming and wiping before a small fire. Where the rivers to be metered are large, and considerable time is necessary for the operation, it is often found advantageous to construct a small shelter of poles and canvas in order to protect the meter and the operator. As far as possible, winter measurements should be taken on the same section as those under summer conditions. If this is not found possible, or conditions prevent accurate measurements at the old station, a new station may be selected, but if such is done, care should be taken to refer the auxiliary gauge installed to the datum of the summer station, and sufficient soundings should be taken at the new station to develop the cross-sectional area.

The location for winter stations where ice cover is involved should be well below any stretch of open water where the formation of frazil or anchor ice might occur, and clog the section. It is preferable to locate the section above a rapid or fall if possible; even though the formation of an ice sheet occurs, the presence of such fall or rapid below the section will tend to eliminate any backwater effect due to the clogging of the channel below the station, and hence the gage readings will indicate more closely the actual discharge from time to time.

The gage at the station should be read daily and the thickness of the ice and the depth of the under surface of the ice below the water surface also noted. A record of the daily temperature is necessary. The gage readers of this survey have been provided with a thermometer, a device in the form of a modified scaler's rule for reading the thickness of the ice, and where necessary, with an ice chisel. On the forms provided, the gage reading, thickness of ice, depth of ice below water surface, and temperature are recorded; these records are kept in a book, and post cards of corresponding form are provided on which the records are forwarded to the office each week.

## AN ACCOUNTING SYSTEM FOR TOWNSHIP AND DISTRICT ROAD OFFICIALS.

A system of forms for the use of township or district road officials in Illinois for keeping their accounts and transacting their business has been prepared by J. M. McCoy, chief clerk bureau of audits of the Illinois Highway Commission. These forms have been approved by the commission and are now in use by the local highway officials. The various forms are shown below.



STATE OF ILLINOIS

County........ . . ..... .... . Town or District .... . ..........

INVENTORY

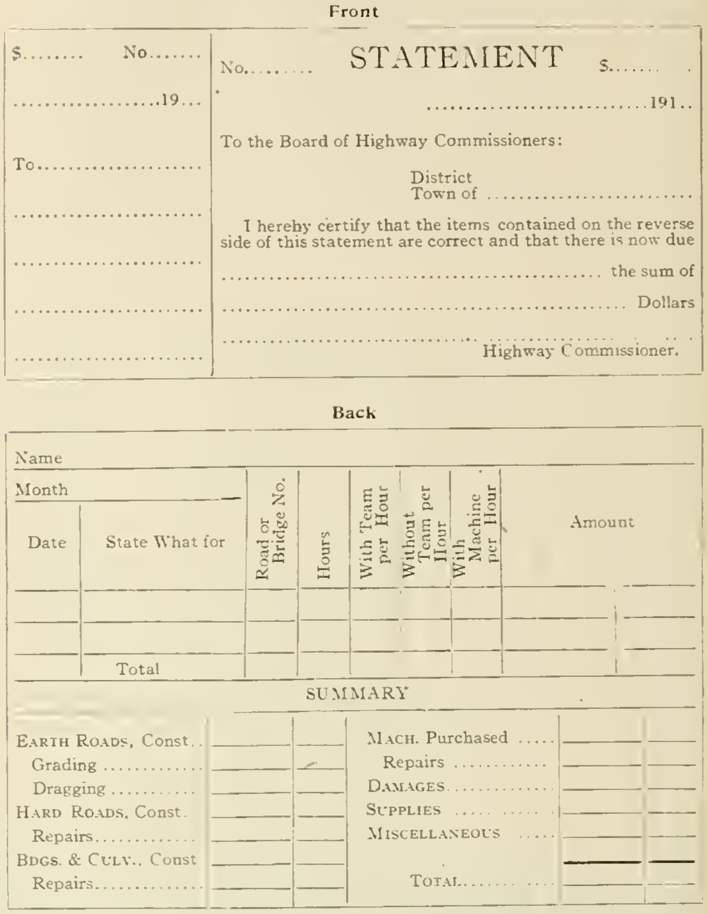
MACHINERY, TOOLS, ETC., Owned by Town or District May 1, 19. .

| Article | Condition | Size | By Whom Made | When Purchased | Cost | |
|---|---|---|---|---|---|---|
| | | | | | | |

Form 1—Inventory Blank. Actual Size, 8½ In. x 14 In.

Form 1 is the inventory blank. This inventory of machinery, tools, etc., is made annually on the first of May. As is called for in this inventory blank, a completed inventory is filed with the town clerk and copies furnished also to the county superintendent of highways for his information.

Form No. 2 shows the order by road commissioners on Board of Highway Commissioners to pay out road funds. This form is to take care of any particular work which is done under the supervision and authority of any one member of the Board of Highway Commissioners. It is filled in and signed by the Commissioner in charge and approved by the Board of Highway Commissioners at their subsequent meeting and filed with the town clerk.



Front

$........ No.......

.................19...

To.....................

.......................

.......................

.......................

.......................

No.........

STATEMENT

$.......

............................191..

To the Board of Highway Commissioners:

District
Town of ..........................

I hereby certify that the items contained on the reverse side of this statement are correct and that there is now due

..................................................... the sum of

..................................................... Dollars

.....................................................
Highway Commissioner.

Back

Name

Month

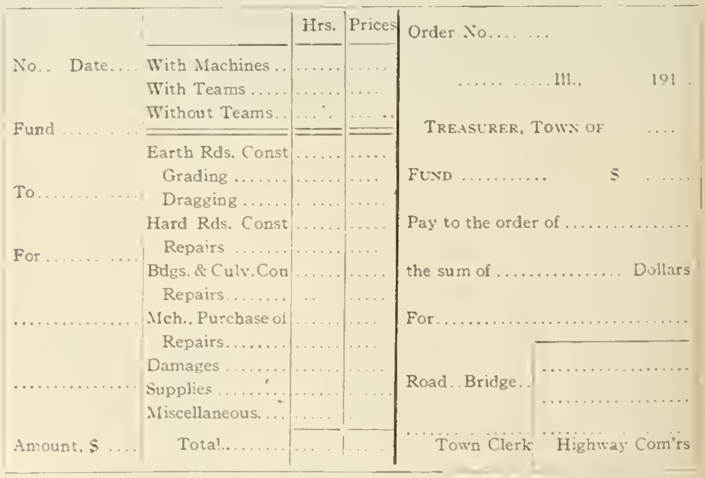
| Date | State What for | Road or Bridge No. | Hours | With Team per Hour | Without Team per Hour | With Machine per Hour | Amount | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | Total | | | | | | | |

SUMMARY

| | | | | | |
|---|---|---|---|---|---|
| Earth Roads, Const.. | | | Mach. Purchased ..... | | |
| Grading ............. | | | Repairs ............ | | |
| Dragging ........... | | | Damages............. | | |
| Hard Roads, Const. | | | Supplies ..... ..... | | |
| Repairs.............. | | | Miscellaneous ..... | | |
| Bdgs. & Culv., Const | | | | | |
| Repairs............. | | | Total....... .... | | |

Form 2—Order by Road Commissioners on Board of Highway Commissioners. Actual Size, 12 In. x 4¼ In.

It is important that this order be filed with the town clerk as he must have a record of all business transacted at a meeting of a Board of Highway Commissioners and a failure on his part to keep such a record renders the action of the highway commissioners void and in some cases illegal. This form provides for classification of the work for which funds are expended, which should agree with the order blank, Form No. 3. It is important that this classification be filled out so that the town clerk may



No.. Date....

Fund ..... . . .

To......... ....

For ........ ....

...............

...............

Amount, $ ....

| | Hrs. | Prices |
|---|---|---|
| With Machines .. | ...... | ..... |
| With Teams ..... | ...... | .... |
| Without Teams.. | ...... | .... .. |
| Earth Rds. Const | ...... | ..... |
| Grading ....... | ...... | .... |
| Dragging ...... | ...... | ..... |
| Hard Rds. Const | ...... | ..... |
| Repairs ....... | ...... | .... |
| Bdgs. & Culv. Con | ...... | ..... |
| Repairs........ | .. | ..... |
| Mch., Purchase of | ...... | .... |
| Repairs........ | ...... | .... |
| Damages ....... | ...... | ..... |
| Supplies ....... | ...... | ..... |
| Miscellaneous.... | ..... | |
| Total.......... | .... | .... |

Order No.... ...

...... ......Ill., 191 .

Treasurer, Town of ....

Fund ........... $ . ....

Pay to the order of ................

the sum of ............... Dollars

For.................................

Road..Bridge..

.................. ..................
Town Clerk Highway Com'rs

Form 3—Order of Highway Commissioners to Pay Out Funds. Actual Size, 12 In. x 4¼ In.

make an intelligent distribution of the disbursements of the funds provided for in the order.

Form No. 3 shows the order of highway commissioners to pay out funds. This form is an order of the highway commissioners directing the treasurer to pay out funds and is signed by at least two highway commissioners under the three commissioner system, or by the single highway commissioner, where the latter system has been adopted.

STATE OF ILLINOIS

..............Highway Treasurer in Account with {District Town} of..........County..............

Fund........................

| DATE | TOTAL RECEIPTS | AMOUNT | DATE | TOTAL EXPENDITURES | AMOUNTS |
|---|---|---|---|---|---|
| | From Whom Received | | | Semi-Annual Summary of Expenditures | |
| | | | | | |

Right Hand Page.

STATE OF ILLINOIS

..............Highway Treasurer in Account with {District Town} of..........County..............

Fund........................

| Date | TOTAL RECEIPTS | AMOUNTS | Date | TOTAL EXPENDITURES | AMOUNTS |
|---|---|---|---|---|---|
| | From Whom Received | | | Semi-Annual Summary of Expenditures | |
| | | | | | |

Left Hand Page.

Form 4a—Right and Left-Hand Pages of Book for Sheet for Recording Summary of Receipts and Expenditures. Actual Size, 28 In. x 8½ In.

Space has been provided on this form for the signature of the town clerk. This signature is not required by law but in order that there may be a proper record of the proceedings and that the township treasurer may know that the town clerk has made a proper record of this order, it has been deemed advisable that the signature of the town clerk appear on all such orders. The classification of the expenditure of funds contained in this order agrees with the classification on Form No. 2 as well as the classification of the treasurer's record book.

OF.............STATE OF ILLINOIS. ..........................TREASURER.

| EARTH ROADS | | | HARD ROADS | | BRIDGES & CULVERTS | | MACHINERY | | Damages Roads Ditches | SUPPLIES | MISCELLANEOUS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Construction | Grading | Dragging | Construction | Repairs | Construction | Repairs | Purchase of | Repairs | | | | | |
| | | | | | | | | | | | | | |

Right Hand Page.

ROAD AND BRIDGE EXPENDITURES {DISTRICT TOWN} OF..........................COUNTY

| DATE | TO WHOM PAID | FOR WHAT | Order Number | Road or Bridge | TIME HOURS | | | | FUND | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | With Team | Without Team | With Machine | Per Hour | General | Hard Roads | | |
| | | | | | | | | | | | | |

Left Hand Page.

Form 4b—Sheet for Classification of Expenditures. Actual Size, 28 In. x 8½ In.

Form No. 4 is a sheet for the record book for use of town treasurer. This book is to consist of two sections; the first section being made up of about 40 or 50 sheets of Form 4a, which will serve for recording a summary of the receipts and expenditures. The balance of the book is made up of pages similar to Form 4b which provides for a classification of the expenditures recorded in the summary in the front of the book. This record book is somewhat similar to the treasurer's book sent out two years ago by the State Highway Commission.

Form No. 5 is the blank used for a report to the county superintendent of highways of the receipt and disbursements of the township funds. The purpose of this form, which should be made out each month and certified to by the town clerk, is to give to the County Superintendent of Highways such information as is necessary for him to have in carrying out properly the duties of his office.

Form No. 6 is a page from the record book kept by county superintendent of highways in order to obtain information relative to financial conditions of various townships. It is not the intention that this book should be kept in detail as to the amount of expenditures but only as to show, monthly, a summary of each monthly report thereby enabling the county superintendent at any time to get at the financial condition of each township. This information is necessary in order that he may be properly informed as to the financial condition of the township when he is asked for approval of all contracts in excess of $200.

STATE OF ILLINOIS REPORT TO COUNTY

Receipts and Disbursements account Road and Bridge moneys for

| Date | RECEIPTS | Amount | Date | TO WHOM PAID | FOR WHAT | Order Numb'r | Road or Bridge | Hours with Team | Hours without Team | Hours with Machine | Per Hour | FUNDS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | From What Source | | | | | | | | | | | General | Hard Roads |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Left Hand Page.

SUPERINTENDENT OF HIGHWAYS County of....................................................

Month of................................, 191 Town or District....................................................

| EARTH ROADS | | | HARD ROADS | | BRIDGES & CULVERTS | | MACHINERY | | Damages Roads Ditches | Supplies | Miscellaneous | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Construction | Grading | Dragging | Construction | Repairs | Construction | Repairs | Purchase of | Repairs | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Right Hand Page.

Form 5—Sheet for Report to County Superintendent of Highways of Receipt and Disbursement of Funds. Actual Size, 34 In. x 9¼ In.

County................................ County Superintendent

| RECEIPTS | DISBURSEMENTS | FUNDS | | | |
|---|---|---|---|---|---|
| | | General | Hard Roads | | |
| | | | | | |
| | | | | | |
| | | | | | |

Left Hand Page.

of Highways Record Book ....................................Township

| EARTH ROADS | | | HARD ROADS | | BRIDGES & CULVERTS | | MACHINERY | | Damages Roads Ditches | Supplies | Miscellaneous | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Construction | Grading | Dragging | Construction | Repairs | Construction | Repairs | Purchased | Repairs | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

Right Hand Page.

Form 6—Record Book Kept by County Highway Superintendent. Actual Size, 28 In. x 8½ In.

APPROVAL FORM
FOR
TOWNSHIP PURCHASES AND CONTRACTS

..........................................191....

At a .............................meeting of the Highway Commissioners

of......... .........................Township. .........................County

State of Illinois, held on the..................day of..................191....

it was decided, subject to the approval of the County Superintendent of Highways, to make Machinery Purchases as follows:

| Name of Firm | Article | Price | Allowance on Old Machine | Net Price |
|---|---|---|---|---|
| | | | | |

to award Road, Bridge and Other Contracts as follows:—

I hereby certify that the foregoing is a correct copy of the records as appears in the minutes of the..........meeting of the Highway Commissioners of..........

Township, held on......................day of......................191....

......................................
Town Clerk.

Approved this .......... .........day of......................191....

......................................
County Superintendent of Highways.

Form 7—Blank for Approval of Town Purchases and Contracts. Actual Size, 8½ In. x 14 In.

Form No. 7 is the approval form for township purchases and contracts. This form is to be made out by the town clerk and attached to all contracts which involve sums in excess of $200. This approval sheet should be made up in triplicate and forwarded to the county superintendent of highways for his approval; one copy is retained by the county superintendent for his files; one copy sent to the town clerk and one given to the treasurer in order that he may know all the requirements of the law have been fulfilled.

## IRREGULAR SUBDIVISION SURVEYS AND COMPUTATIONS.

Contributed by R. Conover.

The majority of real estate subdivisions now being marketed on the Pacific slope, especially around the larger cities, do not follow the gridiron system of layout, the streets being made to conform to the topography. This planning is work for the landscape architect, but the surveyor must be called on for the preliminary topography, the execution of the plan in the field and the computations necessary for the field map. It is the purpose of this article to describe those methods which it is believed are best fitted for this work.

The first necessity is a topographical map, which used in the field and office, gives the architect and his client a basis upon which to lay out the subdivision plan. This should not be taken with too high a degree of precision. The streets themselves occupy but a small percentage of the entire area, and if an attempt is made to cover all the ground with contours exact enough to permit an accurate office location being made the work spent on that part occupied finally by the lots is to a great extent wasted. The requirement to be met is that the grades and location of the roads finally shall not differ materially from those projected, and that fairly clear idea can be had of the exposure and general slope of each lot. No greater accuracy is required than will permit of a general layout being made of a sewer system. The fact that seldom will a road lie below the lots on each side of it makes it necessary to reserve sewer rights of way along side and back lot lines.

A careful survey should be made of the exteriors. From this a skeleton of either chained or stadia traverses should be laid out, following generally the better defined ridges and gullys if such are present. This survey is next mapped on a scale of 100 ft. to the inch on a good quality paper, the bearings and distances of the lines and elevations of points being shown. Topography should be mapped in the field, a party consisting of a topographer, a transitman and a rodman.

The writer has used with success a home-made plane table 20 in. by 30 in. mounted on a tripod, no arrangement being made for leveling. It was found that in ordinary ground a single 2 in. by 4 in. leg with an iron point projecting 6 in. below the square bottom of the leg gave sufficient support. The soil in California in the summer is too hard to be penetrated and a tripod is necessary. A. K. & E. stadia slide rule, fastened to the board and an 8-in. semicircular transparent protractor with a scale marked on its straight edge complete the sketching equipment.

In operation the transit occupys a station, the plate being oriented to read true azimuth. The topographer sets up fairly close to the transit, orienting the table approximately by eye and draws a light meridian line through the station occupied. The rodman having given a "shot," the transitman calls off the rod distance to the topographer who sets it on the slide rule, next the azimuth is called to the nearest 10 or 15 minutes of arc, no attempt being made to use the vernier. The topographer swings the protractor on the needle stuck through the station until it indicates the correct azimuth and holds it with his left hand. The vertical angle is next read by the transitman, and an inspection of the slide rule gives both the difference of elevation and the corrected horizontal distance, the latter usually being considered the same as the rod distance for angles less than 5°.

This method does not of course preserve the notes for future checking, and it may be urged that there is a large chance for error. Stadia notes that are platted in the office are seldom used a second time, however, and the errors that are made are usually such that they are quickly seen and corrected in the field. The same errors being brought into the office cause much more trouble. As many as 400 shots have been taken, reduced, spotted and the topography drawn in a 9½-hour working day. This record of course was made under favorable conditions and 250 is probably an average number. The character of the country and the experience of the men are factors which vary so widely that it would be unwise to give any figures for acreage taken, but it is known that this system gives better results both as to character of work and cost than when notes are taken and the reduction and platting are done in the office.

A blue line print should be made for the architect, the topography stations being shown thereon to enable him to locate himself in the field. He will return it to the surveyor with the proposed plan. It is then the work of the latter to mark in the field the center lines of the roads as shown. The designer should then make a field inspection and indicate where he desires changes. If this is not done it is extremely annoying to figure balanced road centers and lot lines and then repeat the work to satisfy the artistic sense of the designer. This procedure is urged with a depth of feeling that cold print cannot convey.

The one great difficulty of this work is that the map as finally placed on record should be trigonometrically accurate; in other words it should "close flat." For while it is understood that no such survey can be actually accomplished, it is impossible to retrace the survey of a lot that does not close and the errors in the field work can usually be held down to such a quantity that when spread over the perimeter of a block the resulting difference from the field returns is negligible.

In subdivision work the curvature is designated by the curve radii and curve distances shown are along arcs. The character of street alignments is usually in one of two classes: The first where tangents predominate, and the second where there are principally curves. In the first class the P.I.'s are set and the work done somewhat similarly to railroad location, the corrections in closures being made in the tangent bearings and distances. The second class, however, presents a more difficult problem when the attempt is made to perfect a closure. Short tangents (less than 10 or 15 ft.) should not be left between curves as it makes a complicated map. They should either compound or reverse directly, and the computer in balancing the survey is confronted with either making large changes in the few short tangents or in the distances between the P.I.'s, the difficulty of the latter method being that the subtangent distances on each side of a P.I. must be kept equal.

There are two methods for a solution. In the first, assuming that the grade approaches the maximum allowable, a chrometer line is run along the approximate location, a stadia survey follows this and the points so taken are platted fairly close. The road center line is projected, the point of compound and reverse curve being marked. These points are then set in the field from the nearest stadia station, bearings and distances being scaled. A tack is set in the center of each stake and finally a careful traverse line run over the latter, the notes being the alignment of contiguous long chords. If this is done for each street in the entire subdivision and a closure figured for each block along the long chords, a careful study of the results will make it possible to balance the traverses both as to bearings and distances so that no large correction is applied to any one angle or distance. From these corrected long chord distances and the intersection angles between them the central angles and the radii of the curves may be computed. These, of course, will always be fractional and if it is desired that the radii be arbitrarily chosen, the second method can be followed. In this the reconnaissance is run as before and a carefully chained transit line run over or near it, the points through which it is desired the location shall fall being located by side shots. This line is balanced and closed and the co-ordinates of each transit point computed and the line platted.

The location is now projected with the desired radii and their bearings scaled. A traverse is figured over this projected line to the last point before its junction with the boundary or some other road, the junction itself being computed. From the co-ordinates of these curve points and those figured for the transit line, the necessary data can be obtained to permit the curve points being set. This method involves more work and the final results are not as satisfactory as with the first.

In the computations an origin of co-ordinates should be chosen well to the south and west of any part of the work and co-ordinates figured for each curve point and center. In residential subdivisions the figures shown on the filing map are to side lines of streets. Occasionally there arises work where the lots are sold by acreage and in this case the street centers are considered the property lines and dimensions shown are to them. Distances are shown to the hundredth of a foot and angles to 10 seconds of arc.

A working drawing should be made of each block on a scale of 20 to 50 ft. to the inch, the lines being platted by co-ordinates. The side lines of streets should be shown with "return" curves betwen them at street intersections. The lots should be drawn to conform to the plan. Slight changes can be made which simplify the computations. Thus lot lines which are nearly radial can be made exactly so and those which intersect street lines near curve points can be made to strike those points exactly. The dimensions of about half the lines must be determined from the drawing, those for the rest being computed. If the working drawing is carefully made much time can be saved by scaling both distances and bearings. This is simpler than scaling co-ordinates for the ends of each line and computing the closure between besides giving integral results.

A Brown & Sharpe protractor is very useful in taking off bearings. The procedure is usually to take the main back lot line running through the center of the block and scale distance and bearing for each course but the last, which must be computed. Co-ordinates are figured for each lot corner along this line. Unless the side lot lines are parallel, which is exceptional, it is best to draw the radii from the centers of the street curves to the points where the lot lines intersect the streets, scale the radial bearings and compute the co-ordinates of the lot corners. Co-ordinates for each end of lot lines being thus given it is a simple matter to figure the closing course. The solution of the missing dimensions resolves itself into four trigonometrical cases.

The writer uses Vega's 7 place logarithmic tables, although a Marchant or similar calculating machine used in connection with natural functions is slightly faster for straight traverses and in the solution of arc lengths. Although not usually the custom it is best to show radial bearings occasionally on the filing map, especially near street intersections, for if they are omitted the only way to establish the connection between the street alignments is by the arc of the short radius return curve.

Costs vary with the difficulty of the work, but on ordinary size lots all the preliminary and final calculations can be done at the rate of 10 lots per man per day. A copy of the working map with the necessary dimensions is given the field men who set the lot stakes as a final step.

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## METHOD OF MAKING SURVEYS AND PRELIMINARY DESIGN FOR THE WINNIPEG AQUEDUCT.*

### Location of Aqueduct Line.

The engineering force for the carrying out of the work was organized in the late fall of 1913, and work in the field and office was actively pushed forward to establish the final line. Five field parties were sent out on location for the purpose of obtaining a line with a continuous down-grade as near the average slope as possible between Shoal Lake and Winnipeg. It may be stated here that a line was secured in which more than 36 per cent was practically on the average slope, while the actual increase in the length of the line over a direct air line is only 8 per cent. The difference in elevation between Indian Bay and the surface of the water in McPhillips St. Reservoirs is 293 ft., and the length of the line 97 miles approximately—so that the average slope is 0.57 ft. per 1,000 ft. of length. The comparative flatness of this slope and the necessity for holding the line as near to the average slope as possible rendered it extremely important to have even the preliminary field work carried out in an accurate manner. For this reason one field party was sent out with instructions to establish a line of precise level bench marks, which bench marks were located, as a rule, on the north and south Provincial Range and Section lines at or near the intersections with the preliminary location. The other field parties then ran lines of levels along the north and south Section lines, by means of which the general slopes of the country were quickly established. Contours plotted from these results showed that the country has a very gentle drop towards the northwest. When this mass of data was sent in to head office several trial lines were laid down and the field parties were instructed to run them out. At the same time cost curves were made up in head office showing the variation in the cost of the aqueduct structures at varying depths of excavation, and for varying sizes of aqueduct, the slopes ranging from 0.1 ft. per 1,000 ft. to 1½ ft. per 1,000 ft. By this means the separate field parties were then enabled to adjust the various lines to a minimum cost, taking into account all the varying items affecting such cost, such as the depth of cut, slope and length. Owing to the unsettled nature of the country the camps were practically isolated as communication had to be made by means of runners and supplies packed in on the backs of porters or by canoe up the Brokenhead and Whitemouth Rivers.

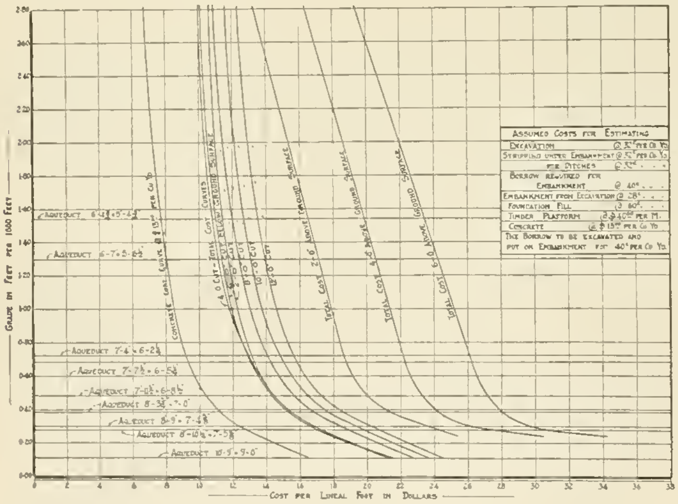

Fig. 1—Hydraulic Characteristics for Arch Aqueduct—Slope 0.6 Ft. per 1,000 Ft.

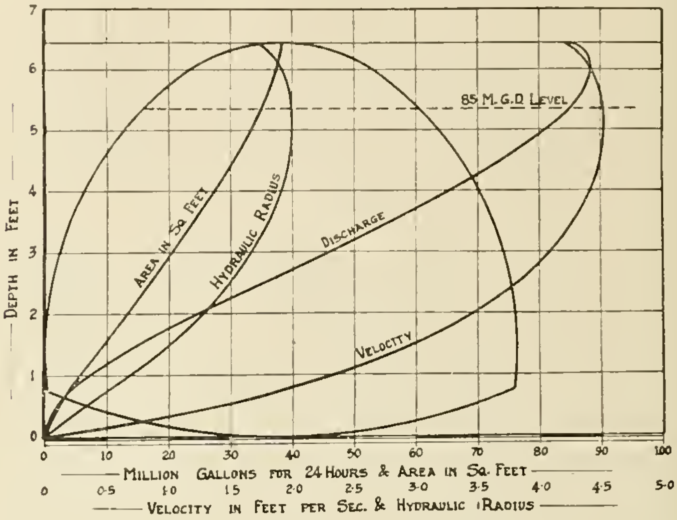

Fig. 2—Ratio of Depth of Excavation and Height of Foundation Fill to Cost Per Foot of Aqueduct for Varying Slopes.

Owing to the flatness of the surface of the country the rain water does not drain off, and on account of the impervious subsoil, which consists of a sandy clay, large areas of swamps, sloughs and muskegs have formed, making the country inaccessible, except in winter time. It was thus necessary to carry the location work forward with the greatest dispatch during the first winter season. The line was located, except for certain short portions, by the beginning of spring in 1914.

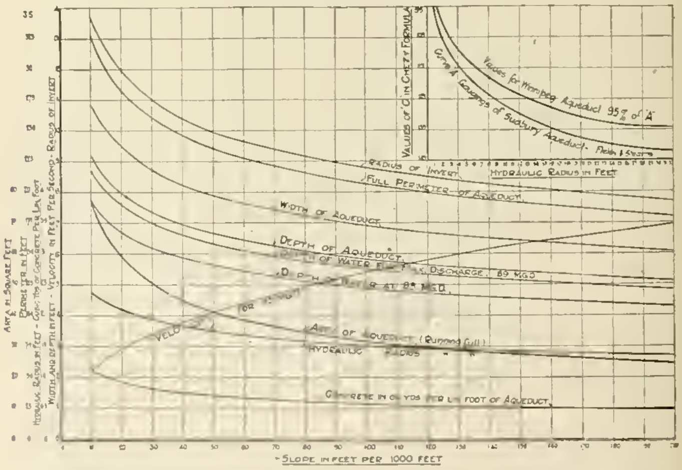

Fig. 3—Relation of Dimensions of Aqueduct Sections to Slope.

The following figures show generally the amount of work covered by the five field parties during the winter season from the time they started out until the line was located: 362 miles of transit lines; 1,317 miles of levels; 95 miles of precise levels; 380 square miles topography.

Borings were also made during the process of location to determine the depth of the overlying muskegs. Some 12,000 ft. of borings were made and recorded. It may be added that the expeditious manner in which the work was carried out reflects great credit on all of the field parties engaged.

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*From a paper presented before the Canadian Society of Civil Engineers by W. G. Chace, Chief Engineer of the Aqueduct, and M. V. Sauer, Assistant Chief Engineer.

The necessity for active co-operation between head office and the various field parties can readily be seen in order that the results obtained might be co-related before any one party had gone too far. The cost curves mentioned above, one of which is shown in Fig. 1, were of material assistance in this regard.

### Preliminary Design.

While the field work was in progress active work in head office was carried out on the details of design and layout. It was soon recognized that the utmost refinement in design was required to keep the cost of the work within bounds; for example, it may be pointed out in this regard that the addition of 1 in. thickness to the aqueduct section would add over $400,000 to the cost of construction.

To determine on the type of aqueduct structure to be adopted, studies were made of the economic and hydraulic characteristics of various concrete arch types and of a reinforced concrete box type. This latter had some advantages from an economic point of view, but the question of the life of reinforcing steel with thin concrete covering threw doubt on the desirability of its use for an aqueduct to deliver a permanent supply to a rapidly growing city like Winnipeg, and such a type would be much less rapidly built than an arch or self-supporting type. If the concrete sections were thickened up sufficiently to furnish an undoubted protection to the steel, the economies of this type disappeared and left the advantage to the concrete arch.

The varying slopes of the aqueduct required different sizes of sections to accommodate the varying velocities. In analyzing the arch stresses the maximum and minimum sizes were examined and treated for various conditions of backfill loading both with the aqueduct running full and standing empty. The backfill consists of varying types of soil, principally clay and muskeg. It was decided that the type of arch lying betwen the semi-circle and the parabola was best fitted to resist the backfill stresses. Where the foundation for the structure is found to be of a rigid nature the invert is not reinforced, but in the instances where it is found necessary to place foundation fill to replace soft material, or to bring the aqueduct up to grade line, or where the foundation is not unyielding, reinforcing steel is being placed in the invert.

In order to arrive at the proper sizes of sections for the varying slopes the curves for area, velocity, discharge and hydraulic radius were plotted for the maximum and minimum sections and for several intermediate sections. A typical curve sheet is shown in Fig. 2. As the sections from which these curves were plotted corresponded to definite slopes, a series of curves were then plotted on the basis of slope in feet per thousand as abscissae, and the dimensions of the sections and hydraulic characteristics as ordinates. By plotting up points from the individual curves at the 85,000,000-gal. level and joining these up with smooth curves the dimensions of the aqueduct sections were then readily obtained for any slope. These curves are shown in Fig. 3. Similar curves were laid out for all the governing dimensions entering into the design of the sections.

For determining the discharge of the various sections, the values of coefficients as stated in several published reports on other similar structures were studied. Those of Fteley and Stearns made on the Sudbury aqueduct were used as a basis for determining the value of "C" in the Chezy formula, as the general conditions and size of this structure seemed to correspond most nearly to the Winnipeg aqueduct. The values used were determined by plotting the Sudbury results on the basis of variation of hydraulic radius to the value of "C." A conservative curve was then plotted for "C" for the Winnipeg aqueduct on the basis of the Sudbury curve, less 5 per cent.

After the sections corresponding to the various slopes had been determined, the whole system was laid out in profile, and the hydraulic grade was plotted for various discharges, the 25,000,000-gal. grade being carried from the easterly end of the pressure section to the McPhillips St. reservoirs, and the other discharges to the site of the future reservoir at Deacon. In order that the effect of the transition sections between the various sizes of aqueducts could be taken into account, as well as the velocity heads, this hydraulic grade was plotted back step by step by means of arithmetic integration. The manner in which this grade was plotted can be briefly described as follows: Starting from any point at which the water level is known, the depth in the aqueduct is thereby fixed and consequently the velocity and hydraulic radius are known as well as the value of "C." With these three known qualities the value of the slope is then calculated from the Chezy formula and a line is drawn upstream from the water surface for a short distance. If this line is not parallel to the aqueduct grade new values for "v," "r," and "C" are then determined upstream a short distance from the first point, and the process is then repeated and a new slope is obtained and plotted from the last point determined. In this way the surface slope is carried back step by step, giving the final hydraulic grade shown. Where a large change of section occurred between two adjacent portions of the aqueduct this method of plotting the surface slope gave some interesting results, showing up a wave in one instance at the foot of the transition section.

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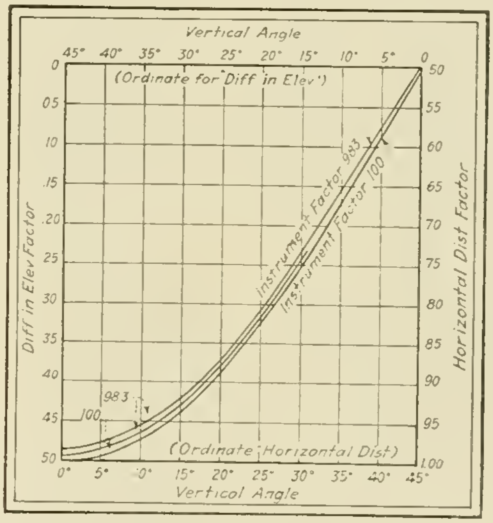
## STADIA COEFFICENT CURVE.

The stadia coefficient curve, shown in the accompanying cut, has been found useful by the Denton Engineering Co., Worland, Wyo., in its field work in mountainous country. A blue print of the curve is inserted in the back of the field books. One of the instruments of the company has a factor of 98.3 and for it two curves are required. The curve for the "V" or "Diff" in elevation is one-half way between the "H" for 98.3 and the curve for 100. This "V" curve can be interpolated near the upper end.



Stadia Coefficient Curve.

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## ECONOMICAL METHOD OF CROSS SECTIONING DRAINAGE DITCHES.

Contributed by B. F. Burns, Office Engineer, Little River Drainage District.

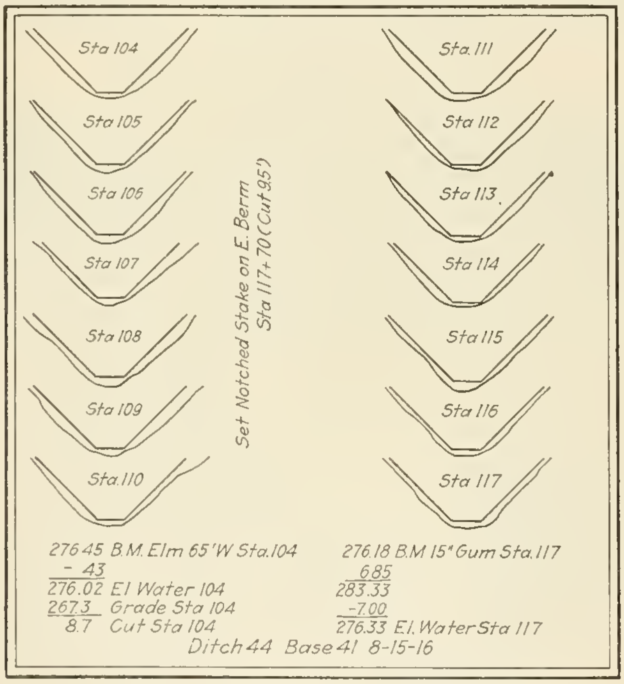
The matter of securing a satisfactory and economical method of handling cross sections has been given some thought and has been a subject of some experiment by the engineers of the Little River Drainage District of Cape Girardeau, Mo. Confronted with the task of constructing 624 miles of drainage ditches, ranging from 4 ft. to 123 ft. base width, and with construction work in progress simultaneously on 24 contracts, on which the completed work must be cross sectioned bi-monthly, speed and economy in handling that work were worthy of consideration.

When the construction work begun, the notes for each cross section were platted in the office of the resident engineers on sheets 18 in. by 24 in. and then the books and sections were forwarded to the chief engineer's office where they were checked. After the notes and sections were checked, blue prints were made for the information of the contractors. Then the notes, unfilled cross section sheets, and blue prints were sent to the engineer in charge of the residency from which the work came.

After a short period a loose leaf duplicating field book was secured to replace the field book in use and the resident engineer was enabled to retain a carbon copy of his notes in the office, thus doing away with the necessity of exchanging field books and the possibility of loss in transit. No economy in time nor labor was effected as the notes had to be checked as before.

Later one of our resident engineers conceived the idea of platting the cross sections in the field and after some experimenting along that line the present method of handling the work was adopted. That method, briefly described, is as follows:

Cross section sheets 8½ by 11 in., ruled 8 by 10 in., and blocked into pads of 100 sheets, every third sheet plain, were secured from a company supplying drawing materials. A pad of this cross section paper and a stock cover known as the LyFlat sheet holder constitute the equipment on all of the residencies, except where the bottom widths of the ditches are too great for platting, on a scale of 10 ft. to the inch, on the sheets of the size named and then larger sheets are used and special covers supplied. An original and two duplicates are platted simultaneously by interleaving two carbon sheets between the cross section sheets. The original, in pencil, is forwarded to the chief engineer's office, the first carbon is retained by the resident engineer and the second, on a plain sheet, is handed the contractor for his information and guidance should any corrections be necessary in the work included within the reach cross sectioned.

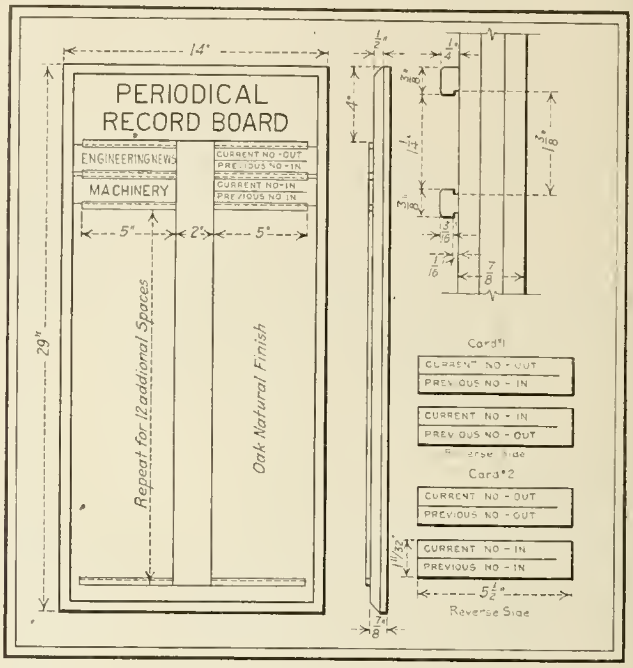


Cross Section Notes on 4-Ft. Base Ditch.

Soundings are taken across the ditches normal to the center line and about 4 ft. apart to develop the excavated prism. Sections are taken at 100-ft. intervals throughout the completed reach; the plusses being varied each month so as to get typical sections. Depths are determined from the water line, which is tied in to bench marks at the beginning and at the end of each reach and the variation, if any, noted. The sounder calls the depths and distances to the party platting and the points are platted direct. After the sounding at any section is completed the points are connected and the specified prism lines platted on the section. This enables the engineer to determine at once whether or not the section is to grade and see how closely the specified prism lines have been followed. There is no delay in issuing orders to the contractor for correcting any defects that may be found in the work. There is no checking of cross section notes in the office of either the resident or chief engineer and no bother with blue prints for the information of the contractor. The method has proved to be one of considerable economy, is altogether as accurate, and is more desirable than the original method used.

## PERIODICAL RECORD BOARD, WASHINGTON WATER DEPARTMENT.

The sketch shows a handy device employed in the Water Department, Washington, D. C., to indicate at a glance what periodicals are "in" or "out" of file. The drawing leaves little to be explained in respect to the construction of the board. The cards are printed on stiff cardboard and on both front and reverse. They are changed to give the proper indications as the periodicals are taken from or returned to file.



Periodical Record Board.

## PERSONALS.

William F. Coleman has been appointed county road engineer of Warren County, Kentucky, with headquarters at Bowling Green, Ky.

R. G. Wyman has been appointed division engineer of the Atchison, Topeka & Santa Fe Ry., Eastern lines, with headquarters at Amarillo, Tex., succeeding J. W. Walter.

Louis C. Kelsey, consulting engineer, has opened a branch office in the Twin Falls Trust Bldg., Twin Falls, Idaho. Main offices will be retained at 410 Selling Bldr., Portland, Ore.

R. B. Burton, senior assistant to the consulting engineer of the Southern Pacific Co., with headquarters in New York City, has tendered his resignation, to take effect Dec. 1, and has accepted a position with private interests.

The Washtenaw Engineering Co. has opened offices at 408 First National Bank Bldg., Ann Arbor, Mich., for the general practice of engineering and surveying. Manley Osgood, city engineer of Ann Arbor and county surveyor of Washtenaw County, is president of the company.

W. C. Pearce has been appointed division engineer of the Chesapeake & Ohio, with headquarters at Richmond, Va. The following acting division engineers also have been appointed: F. D. Beale, with headquarters at Clifton Forge, Va.; J. W. Gleason, with headquarters at Ashland, Ky.; and H. A. Bertram, with headquarters at Peru, Ind.

## OBITUARY.

General Daniel C. Kingman, retired, formerly chief U. S. Corps of Engineers, died Nov. 14 at Atlantic City, N. J., aged 65 years.

Frank O. Sinclair, city engineer of Burlington, Vt., died Nov. 15 at his home in that city, aged 56 years. Mr. Sinclair was graduated from the University of Vermont in 1882 and for the next 10 years was engaged in railroad location and construction in the West and South. In 1892 he opened an office in Burlington for private practice. He was superintendent of the city water department from 1905 to 1907. He also was consulting engineer for the State Public Service Commission.

Hiram Maxim, inventor of the Maxim gun, died Nov. 24 at his home in London, England. He was born in Sangerville, Me., on Feb. 5, 1840. After a meager schooling he went to work in a machine shop and later was employed in the machine works of his uncle, Levy Stevens, at Fitchburg, Mass. He went to England in 1881 and was knighted by Queen Victoria in 1901. In 1894 Sir Hiram invented a heavier than air flying machine, which raised itself from the ground, carrying a driver and passenger. In addition to his gun and aeroplane, he patented many electrical inventions, including incandescent lamps, self-regulating current machines, and several pieces of ordnance. He was a member of the American Society of Civil Engineers

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Halbert P. Gillette, *President and Editor*

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## CALIFORNIA AND NEW JERSEY VOTE BIG SUMS FOR ROADS.

Bond issues of $15,000,000 in California and of $7,000,000 in New Jersey were approved at the polls, Nov. 7. The California appropriation will not be available till next July, however, and the New Jersey appropriation may never be available.

California has already expended nearly $18,000,000 on 1,400 miles of state roads. The money has been so wisely spent that another $15,000,000 is forthcoming for a continuation of the excellent work.

New Jersey, the pioneer in "state-aid" roads, has about 9,000 miles of improved roads, many of which were built before the days of automobile traffic. Hence, a large part of this mileage needs an entire resurfacing that amounts almost to rebuilding. The Egan bill, providing for a $7,000,000 bond issue, received a large majority of votes, but the attorney-general says that the bill is void because it specifies the building of 555 miles of roads and provides only $13,000 a mile, which is less than the estimated cost of the work.

The Egan bill specifies a paved width of at least 18 ft. and a total roadway of at least 30 ft., and that the pavement must have a "hard surface and durable character."

Although the State Road Commissioner, Edwin A. Stevens, has estimated that to build the 555 miles in accordance with the provisions of the Egan bill would cost nearly $30,000 a mile, it seems to us that a way may be found to overcome the legal objection that the attorney-general now presents. There is nothing in the bill that specifies the thickness of the pavement, nor is there anything that restricts the use of any suitable base for the wearing coat. The pavement must be 18 ft. wide and of "hard surface and durable character." Why, then, should not the existing macadam be used as the base, and upon this laid a bituminous macadam or asphalt surface? In another editorial article we discuss the question at some length.

## ALL IS NOT NEW THAT'S "NEW."

To older engineers it is frequently amusing to read about this or that "new" method of construction which he remembers seeing or reading about 20 years or more ago. Many an old highway engineer must have smiled, for example, at the "new" idea of building roads entirely of concrete, when this idea began to be exploited a few years ago. In the early 80's—and perhaps earlier—the "all concrete road" was tried in England. In the 9th edition of Encyclopaedia Britannica, under Roads, will be found a description of concrete roads, antedating our first American experiments by a generation. Incidentally, it is there recorded that those English concrete roads failed to give satisfaction under heavy traffic.

Monolithic brick pavements are now being spoken of as a very new invention, yet we have it on the authority of the brick pavement expert, Blair, that on Washington St., Indianapolis, the brick gutters were of monolithic construction 19 years ago. Doubtless some Dutch engineer could cite Holland specifications for monolithic brick pavements a century old. The Romans, it should be remembered, made stone block roads in which the blocks were bedded in cement mortar—made "monolithic." We have previously mentioned the fact that in these columns ten years ago, we described the New York City practice of laying asphalt blocks in cement mortar, thus doing away with the supposedly essential "sand cushion."

Nevertheless a re-invention is often more important than the original one, and deserves the widest of publicity. But some care should be taken in laying claims to novelty, particularly in matters relating to roadwork, for men have been building roads a good many centuries and often in a manner not so fundamentally different from our present practice.

## WHY DO PAVED ROADS OFTEN CRACK LONGITUDINALLY?

Concrete and brick roads so often crack longitudinally, in spite of every precaution, that many engineers despair of ever being able entirely to prevent it. Occasionally a single crack runs down the center of the road, but more often a pair of almost parallel cracks occur, one on each side of the center, dividing the road into three approximately equal parts. What is the cause of this cracking?

One eminent highway engineer thinks that unequal settlement of the subgrade accounts for it. Another regards the unequal saturation of the subsoil and consequent unequal heaving by frost as the cause. But when longitudinal cracking occurs in cuts as well as on fills, and in southern California as well as in northern New York, each of these alleged causes of cracking must either be regarded as no cause or as one of several causes.

It will be noted that the causes commonly assigned for longitudinal cracking are some form of unequal vertical motion of the subgrade. Is it not more likely that a horizontal movement of the subgrade causes the phenomenon? Soil expands when wet and contracts when dry. Cut a ditch on each side of a road, increase the moisture content of the earth "slab" between the ditches, and there will occur a lateral movement of the earth "slab" in opposite directions from the center of the road. Put a concrete slab on the earth "slab" prior to increasing the wetness of the earth, and what will happen? The adhesion of the concrete to the earth will result either in a tensile stress in the concrete slab or a longitudinal crack in the slab; for the concrete slab will be pulled in opposite directions by the laterally expanding earth.

This is a phenomenon that can be demonstrated by a small scale laboratory test. Would it not form a good theme for a graduating thesis?

## A THOUSAND MILES OF BRICK ROADS AND STREETS IN ONE COUNTY.

Cuyahoga County, Ohio, the home of Cleveland, is also the home of the brick pavement. And it is a home ubiquitous, for wherever one rides in Cuyahoga one rides, for the most part, over brick highways. Also, for the most part, they are very good highways. The county roads alone total over 300 miles of brick, and the cities and towns total some 700 miles additional.

The editor was impressed particularly by the number of brick pavements laid on a sandy subsoil without a base of any kind. Many that he saw had been down on residence streets for ten years and looked as good as new.

Some of the more recent brick pavements laid without a base are bedded in an inch of cement mortar, and the joints grouted with Portland cement mortar.

Sections of these brick pavements, where pipe trenches were being dug through them, showed that a well grouted brick pavement is a monolith. When the brick pavement was undermined and chunks of it sledged off, it broke across the center of the bricks irrespective of the location of the joints. This monolithic character is somewhat surprising to anyone who has regarded the adhesion of mortar to brick as being relatively slight. But to secure tenacious adhesion of brick and mortar, there must be no dirt on the brick when laid. Where brick pavements have failed to preserve a smooth surface under traffic, the cause has usually been poor cement joints, and poor joints invariably occur where the bricks are not clean when laid. So a very slight but important precaution must be taken: Wash the bricks well just before laying them.

Although Illinois leads the procession in the number of all kinds of brick produced annually, Ohio leads the paving brick industry. No mean evidence of this fact is had in the brick roads and streets of Cuyahoga County, whose mileage is sufficient to reach from Chicago to New York.

## WHAT IS BEST IN ENGINEERING EDUCATION?

An answer to this question is attempted in a hundred page pamphlet edited by Prof. H. H. Higbie, President, Tau Beta Pi Association. Nineteen major and many minor questions were submitted to members of this honorary engineering fraternity, and the answers are summarized by Prof. Higbie in a very interesting manner. Perhaps the predominently salient conclusions are, first, that extreme specialization should be avoided, and, second, that the prime object of a college training should be the formation of good habits of thought that will endure through life.

A deal of stress is laid upon the desirability of providing a thorough training in written and vocal English, but all other languages are regarded as superfluous by most of the correspondents. In fact Prof. Higbie says: "The belief seems practically unanimous that foreign languages should be the first to go by the board."

The lecture system of teaching comes in for some severe criticism, and it is worthy of note that the majority regard recitations and laboratory work as being more effective training than listening to lectures.

If the main object of an engineering education is to train men in the application of science to economic problems, and if the formation of mental habits of the most effective sort is the basic part of such a training, then it is self-evident, we think, that the best part of an engineering training is not to be had in the lecture room.

We raise this question: Should not the methods of the college approximate more closely the methods of successful engineers in the conduct of their own business and their own self-education? Under the guiding eye of the teacher should not the student be required to do systematically, persistently and enthusiastically, daily tasks of increasing difficulty? Should he not thus be trained by mental coaches as an athlete is trained by physical coaches, rather than be talked at by the hour?

Trained to be a hard mental worker, grounded in the methods of systematic search and research, shown the sources of scientific information, made to understand the worthwhileness of an ability to impress other men favorably, the rest of the engineering education could probably be left to the average students' own ambition and resourcefulness to acquire for himself. American colleges can learn much from the methods of training prevalent in German technical schools and universities. Many of our engineering colleges still resemble too closely overgrown high schools, where the aim of student life is to pass the final "exams."

In actual life men do not attend long lectures daily or cram their craniums with scientific mincemeat carefully preserved till the can-opener is applied.

Let us, for a time at least, have less to say about the subjects taught, and more about the methods of teaching, and still more about the teachers. What young inventor would not "give an arm" to work in Edison's laboratory under the spell of that genius? The inspiration of his presence and the acquiring of the Edison strategy of inventive attack, would richly educate any young inventor. Indeed it has already educated scores of them. We need more of that sort of training in our engineering colleges. Instead we have quizzers by the thousands, lecturers by the hundreds, and mental coaches by the dozen. Let there be more coaches of inspiring character and there will be better engineering education.

## MACADAM AS A PAVEMENT BASE INSTEAD OF CONCRETE, WITH SPECIAL REFERENCE TO THE ROADS OF NEW JERSEY.

Within the last few years engineers have become so saturated with data relative to the economic uses of concrete that many of them are in fair way to forget that other materials are available and often at less cost for equal service.

Not long ago we called attention to the desirability of using dry rubble masonry for small retaining walls in preference to concrete under certain conditions. At another time we pointed out that the "curtain walls" of mill buildings are often made of brick in preference to concrete. It has been several years since we warned engineers against the hasty abandonment of water-bound macadam, simply because automobiles were cutting up its surface. The time seems ripe to renew this warning, particularly since to ignore it may result in seriously retarding road improvement in New Jersey, as well as elsewhere.

In another column we have mentioned the legal predicament that confronts New Jersey, because the approved $7,000,000 bond issue seemingly is not half enough to improve the 555 miles of roads specified in the Egan bill. If we mistake not, nearly all of these 555 miles of roads are old macadam, badly rutted and pitted as a result of years of travel and inadequate maintenance. Yet at an almost nominal cost, old macadam roads can be scarified, leveled and rolled into perfect shape again. The result will not be the "hard surface and durable character" specified in the Egan bill, but it will be the first and most economic step toward that desideration, for an old macadam road thus repaired makes an admirable base for any kind of wearing surface.

The city of Buffalo, for example, did this very thing extensively at one time, and carpeted miles of resurfaced macadam with asphalt pavements that were among the best in the city. There is nothing new in the scheme. Perhaps that is one reason why so many engineers seem to know little or nothing about it. Haven't some of us, as a matter of fact, gone a bit wild in our search for novel solutions of road building problems? May we not do well to pause in our rush for novelty long enough to inquire whether the older engineers are so far behind the times as the younger men like to believe?

Putting the question baldly: Wherein is concrete superior to waterbound macadam as a base for a pavement? The answer, to be a real answer, must be in dollars per square yard per annum, and not in hot air ad libitum.

Macadam, as every experienced road builder knows, passed into disrepute with the advent of the pneumatic-tired automobile. The cementing power of the stone dust binder is not sufficient to resist the suction of the fast moving automobile. But—mark well the distinction—although macadam failed at the surface under automobile traffic, it did not fail at the bottom. In other words, macadam was abraded to pieces from the top down; it was not broken or displaced in mass. It was strong enough to distribute wheel loads over a soft subgrade, although it was not strong enough to withstand the surface action of motor wheels.

This history of the failure of macadam is important. Coincidentally therewith came a steadily falling price of Portland cement, which turned the attention of engineers toward the use of concrete not only for road bases but for road surfaces. In the middle states, and wherever gravel was much cheaper than broken stone, concrete (if lean) became cheaper than macadam at times, and then there could be no question as to its economic superiority over macadam as a pavement base—provided an entirely new pavement was to be built. But where only the wearing surface was to be new, macadam then enjoyed, and should still enjoy, the preference if already the roadbed was covered with an old macadam that required only resurfacing to make it suitable.

There is, in our judgment, so little difference between the merits of concrete and macadam for a pavement base that the choice should ordinarily be determined entirely by ascertaining which of the two shows the lower first cost per square yard of thickness sufficient to distribute the wheel loads. Fortunately no question of durability enters this part of the problem, for macadam as a pavement base is as durable as concrete. Vide some of the very old roads in London.

In city streets it is often necessary to dig out an old macadam when a new pavement is to be laid in order to secure the same grade for the new surface as for the old. But in country roads no such condition makes it necessary to remove an old macadam pavement.

New Jersey and other eastern states have thousands of miles of macadam no longer suitable for road surfaces, but admirably fit to serve as the base for a durable pavement surface. Such a surface of bituminous macadam or asphalt can usually be laid for less than $1 per sq. yd.—often considerably less.

## EDITORIAL COMMENT.

"This is a miserable piece of road. We suggest immediate action toward remedying it." This is the jolt that automobilists of Danville, Pa., give to the road supervisors in retaliation for the jolts the roads give them. Each motorist drops a few circulars imprinted as above by the wayside wherever he bumps the bumps. "Girard" suggests that if this practice spreads to Philadelphia a snowstorm of protesting circulars would bury most of the streets. And almost every other city cries out: "Me, too."

Bad streets are largely the result of bad laws. When we realize that it is neither economic nor right to assess the entire cost of pavement against abutting property owners, we shall amend our city laws so as to distribute the cost of every pavement over the city at large, at least in part. Then we shall have more good pavements.

A marble effigy of the late "Tom" Johnson, several times Mayor of Cleveland, reminds the wayfarer that he is indebted to "Tom J." for the freedom to ride many miles in a Cleveland "trolley" for 3 ct. It also reminds quite a few stockholders of the traction company that American public leaders can, upon occasion, be as unfair as the most bedamned trust that ever "squoze" a competitor to economic death.

Out in Los Angeles there are three muskateers—"One for all and all for one"—who have deftly dragged the city to the verge of a competitive war with the electric lighting companies. These three muskateers—one a ward politician, one a lawyer and one an electrical engineer—have been looking for three lifelong jobs and they think they have hit the trail that leads them to it. So they have been urging, most disinterestedly urging, the L. A. taxpayers to build or buy them a nice little electric plant to play with. Failing to induce the California Railroad Commission to fix as low a price as they had promised the city to buy the plant for, these three muskateers—"One for all and all for one"—now are telling the citizens that a new plant can be built for about half the sum named by the Railroad Commission as the fair value of the existing plant. Doesn't it ever occur to taxpayers that they would occasionally do well to question the advice of such muskateers?

Now comes a self-appointed committee of Montreal engineers and discloses to the public the fact that if the city completes its municipal hydroelectric power plant, it will have invested $1,500 per horsepower of plant capacity! Might not the engineers of Los Angeles follow the example of the engineers of Montreal and donate some of their time in the public interest? Los Angeles, with all its municipal ownership fads, sorely needs the advice of a body of disinterested experts. It will hire no such body. Let the public-spirited engineers of Los Angeles act on their own initiative.

So rapidly does the number of "city managers" increase that we have difficulty in keeping track of the total. At the recent meeting of the City Managers' Association it was stated that there are now 90 cities that have adopted the city-manager plan. There are 36 members of the association, whose new president is Ossian E. Carr, Niagara Falls. In our last week's issue we published four very interesting articles by four city managers. Civil engineers should take the liveliest interest in the progress of the city management plan of government, for it bids fair to open up a great new field of activity for the executive engineer.

According to a state law in Pennsylvania only the cost of the "original pavement" can be assessed against abutting property owners in third-class cities. According to a decision of the Superior Court of Pennsylvania, macadam is a "pavement." If we remember aright, other courts have held differently, but it is a sane ruling to class macadam as a pavement. Moreover, it is high time that the city as a whole stand the cost not only of renewals of pavements, but of the original pavements, at least in part.

"From the above table we see that only 56 per cent of the engineers believe one year of calculus to be essential. We may say then, that the engineering schools have failed to persuade about half the [75] engineers reached by these letters that even one year of calculus is essential to their success." This quotation is from a paper by Profs. Gaylord and Hanus in the October Bulletin of the Society for the Promotion of Engineering Education. The authors secured letters from 75 engineers on the relation of mathematical training to the engineering profession. The majority of these engineers believe that mathematics should be taught for its usefulness as a tool, rather than as a mental training. This apparently accords with the conclusions of many psychologists who believe that the mental ability of one faculty can not be automatically transferred to another faculty, hence that the study of mathematics can give facility of reasoning power only in mathematics.

Plans have been perfected for a national conference to discuss the subject of highway engineering instruction in the civil engineering curricula of universities and colleges. The meeting is to be held Dec. 29, at 8:30 p. m., in the assembly hall of the Automobile Club of America in New York. It is under the joint auspices of the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, the National Automobile Chamber of Commerce, the Automobile Club of America and the National Highway Association.

## COMPARATIVE COSTS OF PAVEMENTS.

To the Editor: I regret that I have not been able to find time until recently to answer your editorial in the Aug. 2nd issue of "Engineering and Contracting"; also the criticism of Mr. Philip P. Sharples in the same issue, and that of Mr. Durham in the Sept. 6th issue, regarding paper read by me before the Second National Conference on Concrete Road Building, February 1916, entitled: "The Possibilities of Concrete Roads in Suburban and Rural Districts Near Large Cities." I am very glad that my paper has finally brought out some discussion, so that disputed points could be answered and the subject clarified.

Both Mr. Sharples and Mr. Durham apparently have not read my paper carefully. I have not striven to compare "incomparables" but to reduce all the types of pavements under discussion to the same common denominator, namely, the gross cost per year to the taxpayer, assuming the same traffic conditions, for this is the only way that the cost of the various pavements can be compared.

Now as to these assumptions (as stated in my paper):

First, It is assumed that the pavements are laid in suburban and rural districts near large cities. In other words, exposed to such conditions of wear and tear that while there would be considerable traffic, the surfaces of the pavement would not be injured by cuts to repair subsurface structures as happens in cities.

Second, That the community has a maintenance organization highly skilled, thoroughly efficient and prompt, and has the proper plant and equipment to do the necessary work.

Third, That the units of cost are assumed for the district immediately about New York City.

Fourth, That the type of pavement selected has been deliberately made, and that it is intended to perpetuate it for a certain number of years. In other words, if water-bound or bituminous macadam had been selected, careful consideration having been given to other types of pavements, it would be renewed with like surface after it has been worn out, and not used as a foundation for another pavement.

Mr. Sharples states that water-bound macadam can be used as a base for other surfaces, mentioning wood block, etc., just as well as concrete, and does not understand why I do not allow for this in my comparison of cost.

In my judgment the average water-bound macadam pavement is not good enough for a base. The example he cites of Dartmouth St., Boston, and Massachusetts Ave., Cambridge, Mass., may be followed where good water-bound macadam with proper foundation has been laid but not at the figure given in my paper, namely: 64.8 ct. per square yard. The macadam pavement above mentioned would probably cost twice this figure. It is safe to assume that the average water-bound macadam roadway ordinarily built in recent years is not, as an average, over 6 in. thick, and after it is worn down a couple of inches, is not, in my judgment, suitable for the base for any kind of a permanent pavement. We are commencing to more and more realize that the actual pavement is really the base, and that the top or wearing surface is secondary, being only temporary at best and serves to protect the base from wear and tear. I repeat, therefore, that I do not agree with Mr. Sharples that the average old worn-out macadam is as good as an old concrete road as a base.

Now as regards the useful life of the concrete pavement. Mr. Sharples thinks that this should not be as much as 20 years. This, of course, is a debatable question, and one in which the judgment of individuals may widely differ. I have made careful examination of the Wayne County, Michigan roads, having inspected these twice; also those that have been well built in New York State in the vicinity of this city. I have not, of course, taken into consideration the poor concrete roads at all, some of which have been laid in the past and will no doubt be laid in the future. Such a one may have been that on Massachusetts Ave., Cambridge, which Mr. Sharples indicates.

Mr. Durham suggests that 20 years' useful life of a concrete pavement is a "wild guess." I would recommend that Mr. Durham inspect personally the highways in Wayne County, Michigan, also those recently built in New York State, and then "read, mark, learn and inwardly digest" the evidence, and there will probably be no more necessity for argument.

It seems to be admitted by every open-minded engineer that the concrete road has made good and is no longer an experiment. It has gone through the same evolution as the reinforced concrete building and bridge. At first there were quite a number of failures in such structures resulting in loss of life and property, but in the course of a very few years by the combined efforts of the designer and constructor, the use of reinforced concrete both in bridges and buildings has given the most satisfactory results and produces the best form of construction in many cases that can be built for the money. When the same degree of skill shall be used in the construction of concrete highways as is now being used in the construction of concrete buildings and bridges there will be practically no more failures of concrete highways.

I am assuming that (as is the case) this time has arrived and that all types of pavement under consideration in my discussion are being constructed by thoroughly capable engineers and contractors in accordance with the highest state of the art. Unless this assumption is made, of course there is no basis for comparison.

Now as to the probable life of the various types of pavement under discussion, and the cost of maintenance. My assumptions are based upon the experience of the years between 1910 to date. There is no use in going back of 1910 because extensive automobile traffic had not then begun. Valuable data can be derived from the records of cities. There are many streets in New York City and other cities where the conditions approximate those of the main country highways; that is, there have been few cuts in the pavement for subsurface structures, and the character of the traffic on such streets is quite similar,—a mixture of automobile pleasure and business vehicles; also horse-drawn vehicles. The records of the Bureau of Highways of New York go back many years, and from these records I have selected certain streets approximating the conditions of country highways taking the averages for sheet asphalt, asphalt block, wood and granite. As regards water-bound and bituminous macadam, and brick, I have taken the figures from the records of the State of New York, for the last five years. For concrete pavements, I have averaged the figures of Wayne County, Michigan, Milwaukee County, Wisconsin, and the New York State Highways.

In Wayne County, Michigan, the cost of maintenance of 130 miles of concrete highways averaged about $30 a mile a year. In Milwaukee County, Wisconsin, the cost of maintenance of 130 miles of concrete averages about $25 a mile a year. In New York State about 100 miles of first class concrete highways cost the State about $125 a mile a year for maintenance.

One hundred and thirty miles of New York State highways comprising water-bound and bituminous macadam roads near cities has cost the State of New York during the last five years an average of over $1,400 a mile a year. These figures are matters of public record.

You question the idea of using averages both for the life of the pavement and for the maintenance costs. I believe that the use of average figures within reasonable limits is the only way to decide whether or not a certain type of road should be considered. The exceptional cases must always be considered on their merits.

The records of the States of New York, Massachusetts and Connecticut show that the average cost to the taxpayer for maintaining water-bound and bituminous macadam for the entire mileage in these states, amounting to about 3,700 miles, is over $1,000 a mile a year for 16-ft. highway. It would seem that it would be unnecessary to further dwell upon such comparisons as are given in order to emphasize the fact that water-bound and bituminous macadam are not fit to be used for important state highways, but still the taxpayers' money is being continuously wasted in doing just this very thing.

My assumption of 2 ct. per square yard (which you question) as to the average cost of repairs to various types of pavements such as concrete, sheet asphalt, wood block, I believe to be very close to the mark. These pavements have different costs per square yard, concrete being much the cheapest and asphalt next. The percentage of repairs is not the same for the different types of pavements.

Mr. Durham questions some of my figures for the life of a pavement, saying that the records of the Borough of Manhattan, City of New York, show their average life to be a little over 14 years.

I am not for one moment assuming that the country highway has as severe traffic or is subject to such damaging conditions as the average asphalt pavement in the Borough of Manhattan, for not only is the traffic on the later much heavier, but the numerous cuts to repair subsurface structures very much shorten the life of city pavements. In no city in America are the conditions so severe on a pavement as in the Borough of Manhattan. We have, however, many asphalt streets in Manhattan and Brooklyn that have been in existence 25 years, and are still serviceable.

Mr. Durham also questions my figures for the construction cost of the various types of pavements. The costs given in my paper were the average for the year 1915 in the Boroughs of Manhattan, Brooklyn and the Bronx of the City of New York, and in the State of New York for State Highways. These prices are very low and should, of course, not be used now as there has been an advance of from 25 to 40 per cent during 1916. As the advance, however, has been nearly in the same proportion for all types of pavements the comparisons I have given between the costs of the various types of pavements will still hold good.

Mr. Durham's query as to what water-bound and bituminous macadam means is rather surprising; I am using the term in its usual sense, i. e., a macadam road treated by the penetration method with bitumen.

As regards the use in my comparisons of such ordinarily expensive pavements as wood and granite, I cite the case of Worcester, Mass., where residential streets are being laid with granite having cement grouted joints. The gross annual cost to the taxpayer for this kind of street in Worcester is less than either water-bound and bituminous macadam would be under similar traffic conditions.

Very truly yours,
Eugene W. Stern,
Chief Engineer in Charge of Highways, Borough of Manhattan, City of New York.

Nov. 8th, 1916.

## THE FEDERAL AID ROAD LAW.

To the Editor: I have read with much interest your open letter to the Chicago Tribune on the Federal Aid Road Law published in your issue of November 1st.

Alabama is most fortunate in being the home of Senator John H. Bankhead, the author of this bill, and the man who by 10 years of unremitting efforts in season and out of season has finally brought about its enactment. By reason of this fact, the Senator himself has so often clearly, comprehensively and personally explained the Federal Aid Road law to us in all its bearings publicly, that it is not only perfectly understood but both press and public are heartily in accord with it.

It is inconceivable that any attack could be made upon the bill by any one who had taken the trouble to study it. National sentiment on the subject has crystallized so rapidly in view of conditions during the last two years, that I hardly think adverse comment can now make much headway or do appreciable harm.

At all events I am glad to say no appeal to the press on this subject is needed in this section of the South where developments are taking place on a scale heretofore never anticipated or believed possible, many if not all of which developments are largely influenced by the great benefits to be derived from competent road building, for which this county and state are properly appreciative of Federal aid.

Under the proper understanding of the bill which we have, it is not the small financial aid extended which we here value, but the setting up of new and more competent standards of road building under Federal supervision, and more than all else the superwise condition which the bill carries of guaranteed maintenance. WE BUILD BUT WE DO NOT MAINTAIN.

Yours very truly,
Geo. H. Clark,
County Engineer.

Birmingham, Ala., Nov. 24, 1916.

## ROAD ROLLERS IN THE CONSTRUCTION OF EARTH ROADS.

A writer in the November Illinois Highways, the official publication of the State Highway Department, calls attention to the fact that the roller can be made to play a very important part in the construction of the ordinary earth road.

An earth road will absorb water in proportion to the density of the surface and the slope of the crown. The slope of the crown of a road is, of course, limited by the safety and convenience of the travelers, that is to say, a road which has too much crown is both dangerous and unpleasant to travel upon by reason of the tilting or slipping of the vehicle. On the other hand, however, there is no such limit to the amount the surface can be compacted and it therefore stands to reason that after we have secured the maximum allowable crown for the road our attention should be turned to the thorough compaction of the surface.

This can be secured by a roller better than by any other means and a thorough rolling will do much toward securing a dense surface, which will retard the absorption of moisture.

The percentage of time that an earth road is in use depends largely on the water content of the earth forming the roadway (this applies of course to all ordinary soils, except sand). If the water is concentrated or localized, the result is an ordinary mudhole and the entire stretch of road will be useless as long as this one mudhole presents a barrier to traffic. However, if the water is not concentrated or localized, but is distributed uniformly, we will have, true enough, a muddy road but one which is more passable, depending on the depth of penetration of the water. It, therefore, follows that any steps that are taken to shed water more rapidly from the surface of the road or to prevent the saturation of the road, will increase the service of the particular road correspondingly.

Accordingly, the use of the road roller on an earth road by compacting the surface, justifies the expense by doing away with soft, yielding spots in the surface, which absorb so much water that even a slight rain produces a bad mudhole, destroying the value of the road until this one particular mudhole is passable.

It must not be thought that a road roller will keep an earth road from becoming muddy or will keep it in shape every day in the year. It will, however, by making the surface of the road uniformly compacted, produce a highway which, when one portion of it is suitable for traffic, all portions are likewise suitable.

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The College of Engineering of the University of Illinois will dedicate its new Ceramic Engineering Building at Urbana, Dec. 6 and 7.

# METHODS AND COST OF RESURFACING AN OLD MACADAM ROAD WITH ROCK ASPHALT.

Contributed by C. R. Thomas, Division Engineer, Kentucky State Department of Public Roads.

Rock asphalt has been used for resurfacing old macadam roads in Jefferson County, Kentucky, for the past three years. This article describes the methods developed from experience obtained in 1914 and 1915 and used in the 1916 work. The work is discussed with reference to the traffic upon the road, the manufacture and properties of the asphalt, the preparation of the base and the construction of the rock asphalt wearing surface.

### Location and Traffic.

The section of road under consideration is a portion of the Dixie Highway, between Louisville, Ky., and Nashville, Tenn. Beginning at the city limits of Louisville a section about 3½ miles in length was completed in 1915 and the work of 1916 consisted merely of a 4½-mile extension of the work of the previous year.

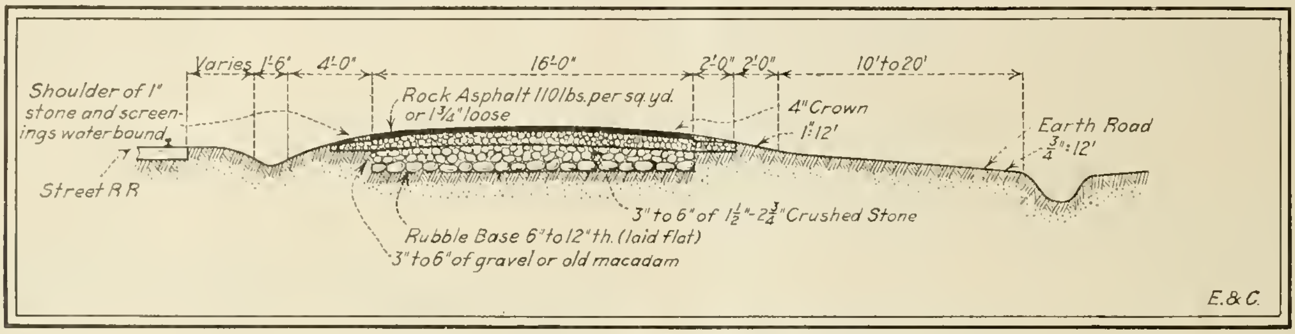
Varies
1'-6"
4'-0"
16'-0"
2'-0"
2'-0"
10' to 20'
Shoulder of 1" stone and screenings waterbound
Rock Asphalt 110 lbs. per sq. yd. or 1¾" loose
4" Crown
1":12'
Earth Road
¾":12'
Street R R
3" to 6" of 1½"-2¾" Crushed Stone
Rubble Base 6" to 12" th. (laid flat)
3" to 6" of gravel or old macadam
E.& C.

Fig. 1—Cross Section of Dixie Highway Resurfaced with Rock Asphalt.

Traffic on this road may be divided into three classes: (1) Garden produce and manure hauling for market gardens tributary to the road for a distance of 15 miles from Louisville. This traffic probably comprises 60 per cent of the total tonnage and is heaviest in the spring and early summer, although much manure hauling is done in the fall of the year. Three and 4-horse loads are frequently hauled. (2) Heavy motor truck traffic is of next importance, including brewery trucks, moving vans and wholesale merchants delivery trucks. This traffic probably comprises 20 per cent of the tonnage. (3) Automobile traffic probably comprises 15 per cent of the tonnage, and the remaining 5 per cent consists of light vehicle traffic with an occasionally heavy load. The automobile traffic probably averages 150 to 200 machines in 24 hours.

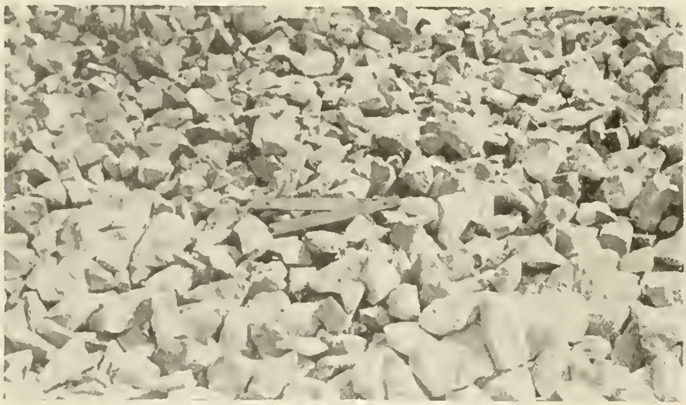

Fig. 2—Texture of Surface Before Rolling Stone Base.

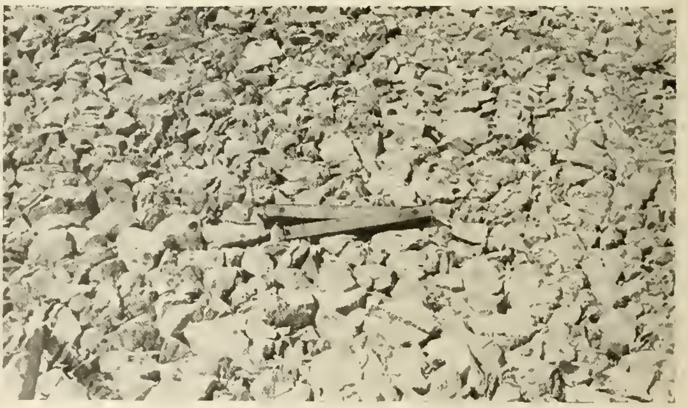

Fig. 3—Texture of Surface After Rolling Stone Base.

### Manufacture of Rock Asphalt.

The rock asphalt so far used on all of the Jefferson County work is quarried and manufactured near Bowling Green, Ky., by the Wadsworth Stone & Paving Co. of Pittsburgh, Pa.

In the quarry from which the raw material was obtained the rock asphalt occurs as a bituminous sandstone ledge varying from 6 to 30 ft. in thickness with an overburden of from 6 to 12 ft. of earth. However, the quarry has not been fully developed. The percentage of bitumen contained in the sandstone varies somewhat and occasionally it is necessary to waste as much as 3 cu. yd. of inferior material to secure 1 cu. yd. of rock containing over 7 per cent of asphalt.

The rock is quarried by the ordinary methods using steam drills and dynamite. It is then passed through an ordinary jaw crusher which reduces it to about the size of macadam stone. The crushed stone is then run through a machine similar in many respects to the ordinary dry-pan used in grinding clay for brick making. The dry-pan pulverizes and thoroughly mixes the material. This machine completes the process of manufacture. The prepared material consists entirely of pulverized bituminous sandstone. The material is then placed in a storage pile, where it remains until loaded into railroad cars for shipment to points at which roads are to be built.

### Properties of Prepared Rock Asphalt.

Rock asphalt prepared for paving purposes resembles in many respects ordinary prepared Topeka specification sheet asphalt paving material, with the exception that at ordinary summer temperatures the rock asphalt is sufficiently fluffy and mealy to be quite easily handled and spread without artificial heating. When the material is spread in a thin layer as in a pavement surface, rolled and subjected to the kneading action of traffic, a thin crust forms on the surface and the pavement becomes hard and smooth. This hardening is perhaps due to compacting and the evaporation of some of the light oils in the crust. Rock asphalt is less slippery than ordinary sheet asphalt and the surface may be patched with cold material.

An interesting property of this material is its tendency to crawl and settle when placed in a pile, and this property is used to advantage in spreading the asphalt. It responds quickly to changes of temperature, especially those caused by a cold wind or a rain. When freshly ground, the material is frequently brownish in color, but turns black upon exposure to the sun.

Upon analysis the material shows a well graded sand aggregate of exceptional sharpness and from 7 to 10 per cent asphalt. The percentage of non-volatile light oils in the asphalt is quite high and that fact probably accounts for the workable consistency of the material at ordinary summer temperatures.

### Preparation of Stone Base.

The old road consisted of a foundation course of sandstone rubble from 6 in. to 12 in. thick, covered with quartz gravel or limestone macadam of greatly varying thickness. The existing wearing surface was oiled macadam, badly worn, but in a fair state of repair.

In resurfacing with rock asphalt it was desired so far as possible to make use of the old foundation, and for that reason few grade changes were made. Figure 1 shows a typical cross section of the finished road.

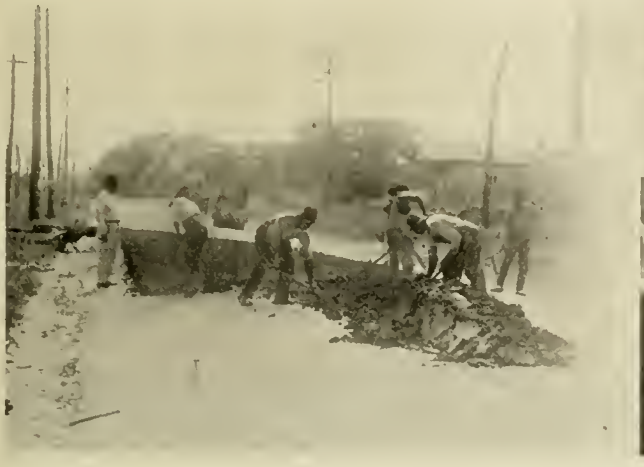

Fig. 4—Spreading Asphalt.

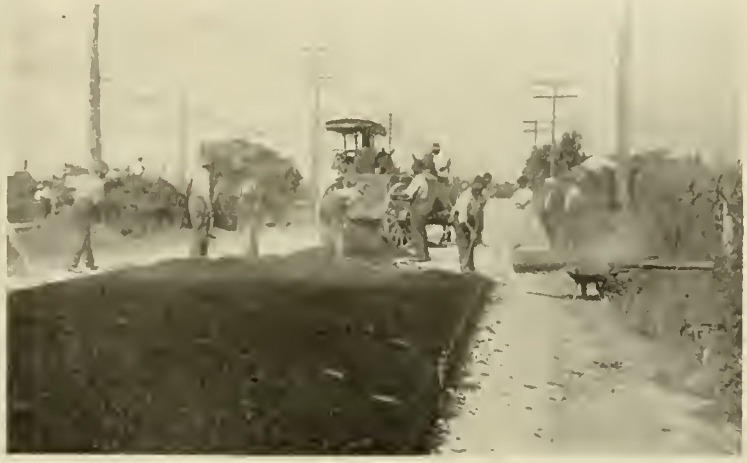

Fig. 5—Dumping and Spreading Rock Asphalt.

As a rule, the following method was used in shaping and scarifying: The ditches and shoulders were cleaned with a road machine, earth being moved in many cases across the entire width of roadway in order to true the cross section of the road. The old macadam surface was then thoroughly scarified in sections about 500 ft. long, and the surface smoothed with a road machine. A Havass block scarifier and a Kelly-Springfield roller with a pneumatic scarifying attachment were used in scarifying. The pneumatic attachment was found to be quite satisfactory, scarifying to any desired depth and leaving no hard spots in the surface. On several sections of the road that had been resurfaced with new macadam the previous year, the loose macadam stone was worked back and forth with the road machine to sift out the dust and leave the clean stone on the surface. Usually the subgrade was rolled very little after shaping, as it was found that the old material reconsolidated quickly, and it was thought that the traffic would find the weak spots in the subgrade more effectively if left unrolled.

Fig. 6—Rolling the Pavement With 7-Ton Tandem Roller.

Fig. 7—Finished Road With Macadam Shoulders.

Two methods of placing the base course of crushed stone were tried, the one last used being a development of the first and considered more satisfactory. The first method consisted of spreading the crushed stone 17 ft. wide, and using a slight earth ridge or shoulder to confine the stone where a considerable thickness was used. In the method last used the crushed stone was spread 20 ft. wide, on a slightly crowned subgrade, and the edges feathered to the thickness of a single stone.

Considerable difficulty was experienced in obtaining crushed stone of a satisfactory size. The stone supplied was a rather soft limestone crushed to pass a 3-in. ring and be retained on a $1\frac{1}{2}$-in. ring. Other stone sizes were tried on a small scale, but with the quality of limestone available were not found to be as satisfactory as the size used.

Stone was dumped in parallel rows and spread by hand. The thickness of spread varied with the amount of old macadam left on the road and the condition of the grades. Since a rigid base is considered essential to the life of a rock asphalt surface no thin or "pancake" fills were made, slight inequalities and breaks in the profile being corrected by increasing the thickness of the crushed stone base. All rock asphalt wearing surface was laid on clean, freshly crushed stone, and even on macadam built the previous year a 3-in. (loose) layer of crushed stone was spread. As a rule, fresh crushed stone was spread an average of 5 in. in loose thickness.

Ordinarily the base was rolled in sections about 300 ft. long, using a 12-ton Kelly-Springfield road roller. After rolling the section was thoroughly barricaded. This method of rolling was found necesary on account of the heavy traffic on the earth side-road while construction work was in progress. In rainy weather traffic would frequently usurp the macadam roadway and travel over the freshly laid base stone. It was found that when the crushed stone base had once been rolled firm it was very difficult to compact a second time, because of the rounded condition of the stone. Also, by sprinkling the stone prior to rolling the dust that rapidly accumulated on the stone in dry weather was washed off and the stone left in a clean condition to receive the asphalt. On account of the uniform size of the stone and the constant danger of its rounding while being rolled, much sprinkling was done in dry weather as an aid in rolling. Rolling was continued until the stone began to crush under the roller, the idea being to secure as firm and at the same time as open a base as possible. Figure 2 shows the surface texture of the stone prior to rolling and Fig. 3 the texture after rolling. It is thought that the degree of smoothness of the finished road depends in a large measure upon the uniformity of texture of the stone base, a variation in texture causing a different degree of compacting in the asphalt and a bumpy surface.

The earth side-road was kept sprinkled in dry weather to keep the dust and dirt from getting on the asphalt and rolled base. It was frequently necessary to sprinkle the subgrade in order to lay the dust before spreading the crushed stone base.

Stone was hauled in 1½ cu. yd. Watson and National dump wagons and 4 cu. yd. Troy trailers pulled by the roller. The maximum haul for both asphalt and stone was about 2 miles and the average haul about 1 mile. After the completion of the first mile of road all the hauling was done in dump wagons.

### Construction of Rock Asphalt Surface.

The prepared rock asphalt was delivered in coal cars at convenient railroad sidings along the road and unloaded by hand into dump wagons and trailers. Ordinary 10-tine stone forks were used for handling the asphalt. In warm weather, if the cars have not been delayed in transit and the asphalt has not been rained upon, the material is handled with comparative ease. The record performance in unloading asphalt was made on Aug. 26 when 60 tons of asphalt were unloaded by 5 men and a foreman in a day of 7½ hours, a rate of 1.6 tons per man-hour. In cold, windy weather unloading is slow and expensive since the asphalt must be loosened with picks. Under average conditions asphalt was unloaded at a rate of 1 ton per man-hour.

Asphalt was dumped in the center of the rolled base in such manner that the material when spread covered the road for the length of the dump. As a rule, two dumps were necessary for each 1½ cu. yd. load. Iron pins located by careful measurement from reference stakes placed at intervals of 50 ft. along the ditch line, were set to indicate the edges of the pavement, and lines stretched between them to serve as guide lines in spreading the asphalt. Figures 4 and 5 show the methods used in dumping and spreading the asphalt.

The asphalt spreading gang ordinarily consisted of 6 men and a foreman, 3 men forking and carrying to the rakers and 3 men raking. This gang spread from 400-600 ft. of 16-ft. pavement in a 10-hour day, depending largely upon temperature and other weather conditions. In spreading the forkers deposited each forkful in a lump and the rakers worked the lump down by pushing on it with the corner of the rake. The teeth of the rake were used to smooth the asphalt after the lumps were disintegrated. Rakes and forks were heated in a fire kept burning in an iron wheelbarrow that was rolled along as the work progressed.

The depth of spread necessary to secure a satisfactory surface varied somewhat with the temperature, in cool weather a thicker spread being required. Generally the asphalt was spread to a loose depth of 1¾ ins., corresponding to a rate of from 18 to 20 sq. yd. to each ton.

After spreading, whenever possible, the rolling was delayed for several hours to permit the material to work down and settle. In a few hours after spreading, if the sun is shining, the asphalt will appear oily, indicating a good condition for rolling.

The asphalt spread each day was generally rolled late in the afternoon, using a 7-ton Kelly-Springfield tandem gasoline roller. The first rolling was done at very slow speed. A water spray connected with the exhaust pipe of the roller was used to keep the rear roll wet when rolling in hot weather, and little difficulty was experienced from asphalt sticking to the rolls. After rolling the section completed was immediately barricaded. The road was then again rolled on the second and third days after completion and then thrown open to traffic.

As soon as convenient after the completion of the surface, clean limestone chips were spread along the edges of the asphalt and rolled with the tandem roller. The chips were then covered with limestone screenings and again rolled. At convenient times and after rains the shoulders were rolled until a waterbound finish was obtained.

Ordinarily, the first three weeks after the road was thrown open to traffic the asphalt behaved badly, picking up under animal traffic and sometimes rutting slightly under heavy loads. Automobile traffic did not affect it much. When the weather was hot and dry the tandem roller was used occasionally to smooth the finished road. After about three weeks' pounding of traffic practically no trouble was experienced, the surface smoothing out and presenting an excellent appearance. Figure 7 shows the completed road.

Patches are readily made with cold material. A rectangular area is chopped out, leaving the edges square, the base rock loosened and tamped by hand, and fresh asphalt spread, allowing about 1 in. for compacting. The edges are then lightly tamped and the patch rolled, leaving the patched place a little high. Frequently the asphalt removed can be mashed up and again used in making the patch. Spots where gasoline or kerosene has been spilled on the road should be watched until the oil evaporates, or a patch may be made at once. After the road ages a few months light oils have less effect on the surface of the asphalt.

### Cost and Personnel.

The contract prices on the work were as follows:

| | |
|---|---|
| Excavation, cu. yd. | $0.25 |
| Scarifying and shaping, sq. yd. | .03 |
| Crushed stone in place, cu. yd. | 1.58 |
| Rock asphalt surface in place, sq. yd. | .08 |

Rock asphalt was purchased by the county at about $5.50 a ton, f. o. b. Louisville, Ky., and delivered to the contractor at the railroad siding nearest the work.

The road was built jointly by Jefferson County, J. R. Gaines, County Engineer, and the Kentucky State Department of Public Roads, Rodman Wiley, Commissioner, as a State Aid Road. Mr. H. E. Read was the State Division Engineer for the work, and Michael Flahraty and C. R. Thomas, County and State Inspectors. The G. W. Gosnell Co. of Louisville, Ky., was the contractor.

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The maintenance survey of concrete pavements in the United States recently undertaken by field engineers of the Portland Cement Association is progressing satisfactorily. According to late reports, nearly 20,000,000 of the 70,000,000 sq. yd. of such pavements have been examined and reported upon and it is expected the work will be completed during the course of the next month. Over 100 engineers stationed in various parts of the country are making this inspection. One of the objects of this survey is to secure data based on actual experience so that methods of construction and maintenance that have produced the best results may be definitely determined with a view to raising the standards of practice in concrete pavement construction generally. When this work is completed, the Portland Cement Association will have a complete history of all concrete pavement in the United States—roads, streets and alleys.

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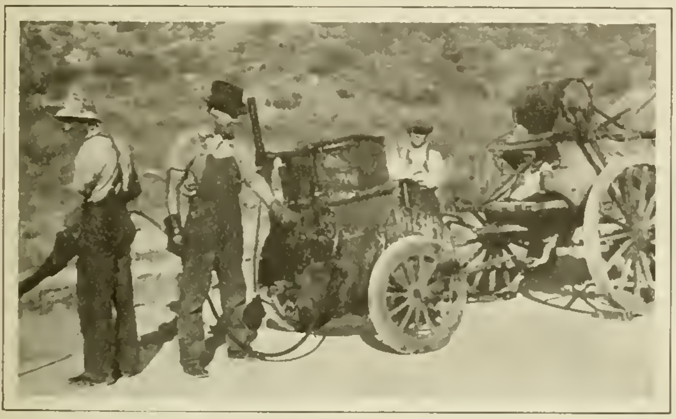
On Nov. 18 the new gymnasium of the Stevens Institute of Technology was dedicated with appropriate ceremony. The building, which was erected as a cost of over $125,000, is the gift of Mr. William Hall Walker of New York to the college. The gymnasium is elliptical in shape, and is, as far as is known, the first of this form to be built. It contains a 10-lap track, a large drill court, and the regulation college pool, and its interior construction includes a number of interesting and original features.

## METHOD AND COST OF FILLING JOINTS IN BITUMINOUS SURFACED CONCRETE PAVEMENTS OF SAN BERNARDINO COUNTY, CALIFORNIA.

Difficulty in making a bituminous carpet stick over the expansion joints on the 87 miles of recently constructed concrete pavement in San Bernardino County, California, led to the invention of a special joint-filling machine, which has proved a success in use.

The pavements are of 1:2:4 concrete, 5 in. thick, and are finished with a wearing surface or carpet of asphaltic oil and screenings. Expansion joints of the Carey sandwich type were provided at intervals of from 30 to 75 ft., depending on the season and relative humidity at the time of placing the concrete. Generally expansion followed the uncovering of the pavement after construction, forcing the joint filler nearly all out. The ejected asphalt was ironed out into a mat over the joint, which did not adhere to the concrete, and as a result formed a weak spot under the asphalt carpet coat that was afterward applied, so that it would not remain over these places.

To remedy these defects it was found necessary to dig out the joints to a depth of ½ in., clean the adjoining pavement and refill the joint with 90 per cent asphaltic oil, heated to a temperature of over 200° F. To do this economically it was necessary to have a machine different from any on the local market.



Asphalt Joint Filling Machine of San Bernardino County, California.

After experimenting and making several changes, the machine shown in the accompanying illustration was perfected. This device consists of a 100-gal. drum mounted on a pair of Ford automobile wheels. Beneath the drum is a firebox containing four distillate burners. These burners are supplied from a small drum carried on the front vehicle and connected to the burners by a flexible hose. The burners are the ordinary gas burners as used in gasoline stoves. The firebox extends to the first band on the drum or about one-third the height of the drum and the connection between the firebox and band is not tight, which leaves a space for draft all around the drum.

The hot asphaltic oil is drawn from the drum and sprayed through a chisel-shaped nozzle by a hand power rotary pump. A by-pass connects the discharge line with the top of the drum so that the oil can be circulated when the machine is not in use, to prevent the pump and lines from cooling and clogging.

The burners are generally kept burning low at night to prevent the oil from cooling, as it takes about three hours to reach a sufficient temperature to spray. It is usually necessary to clean the pump and discharge line either at night or in the morning with distillate. When the nozzle has not been in use for a few minutes the oil becomes cold in the hose, but by placing the end of the nozzle in the top of the drum and rotating the pump a few times the line is heated so that the oil will flow readily. The nozzle is made of ¾-in. pipe and is connected to pump by a ¾-in. flexible steel hose about 10 ft. long. The pump is a Trahern hand rotary pump with a 2-in. suction and a 1-in. discharge.

The oiler is filled at a central heating plant and is towed to the work or filled from 5-gal. buckets distributed along the road. The heavy asphaltic oil in the buckets must be heated before it can be emptied into the drum.

The thickness of the coat of oil applied can be regulated by the rate of rotations of the pump and by a valve in the discharge line under the control of the nozzleman. It is surprising how thin a coat can be applied by this machine, but the oil has to be at a temperature of 300° F. to obtain the best results.

One excellent feature of the machine is its light weight. A trailer attachment was made and bolted on to the rear spring of a Ford automobile by which the machine can be towed to and from the work when necessary. In ordinary use it is towed behind a wagon, the connection being made by a similar attachment bolted to the rear axle of the wagon. A swivel joint in the end of the iron tongue makes a flexible joint that allows no slack in starting and stopping, but allows ample freedom in turning. On small jobs of patching the auto can be used, but for the continuous work of filling joints it was found advisable to use the wagon, as the screenings for filling in and all necessary tools can be carried on the wagon.

The best success in patching joints is obtained by using hard rock screenings passing a ⅜-in mesh screen. The joint is partially filled with oil and the screenings applied to take up the oil. Any surplus oil coming up to the surface of the screenings is taken up with sand or dust. As this surplus oil must be removed before the wearing surface is applied anything to keep traffic from picking up the oil will do to take up this surplus oil.

To protect the refilled joints prior to the application of the wearing surface it is necessary to use a surplus of oil in filling them. In order to avoid a bump, after the wearing surface is applied, the surplus of oil at the joint is removed, which is best done by using a mattock or a hot spade just in advance of the application of the wearing surface.

The crew ordinarily consists of a foreman, pumpman, nozzleman, one man to shovel screenings, one man to sweep, two men to pick out the joints, and teamster and team hauling about 2 cu. yd. of crushed rock screenings and towing the oiler. This crew has finished joints on 48 miles of road in one month at a cost of about $10 per mile. The oil and screenings had to be hauled from 5 to 35 miles. The outfit can cover from 1 to 5 miles of road per day, depending upon its condition.

The original cost of this machine came to about $200, but a duplicate could be built at a lower cost, as some experimental work was necessary before satisfactory results were obtained.

J. S. Bright, Jr., San Bernardino, Cal., is Chief Engineer of the San Bernardino County Highway Commission.

## SOME NOTES ON STATE HIGHWAY MAINTENANCE IN MAINE.

At the close of the season of 1915 195½ miles of completed state highways in Maine were under constant patrol maintenance. This mileage was divided as follows as to type of surface: Bituminous macadam. Portland cement concrete. Water-bound macadam. Gravel.

The following notes on this work are taken from the recently issued report of the State Highway Commission:

**Bituminous Macadam.**—The bituminous macadam, where necessary, was patched early in the spring and such sections as needed it were given a very light surface treatment of Tarvia-B followed by a light coat of sand.

**Portland Cement Concrete.**—The Portland cement concrete sections were completed in 1913 and are either 10 or 12 ft. in width with 4.5 ft., or 5.5 ft. shoulders of water-bound macadam. The concrete surfaces were given a blanket coat of Tarvia-A and sand when constructed. These blanket coats have never been renewed but during the year some patching was necessary, probably not over 5 per cent of the surface needing attention. The principal difficulty was in keeping the shoulders up to surface especially on the insides of curves, although some difficulty of a similar nature was experienced on the outsides of curves, as well as on the whole length of this section. Traffic over these sections is so heavy on holidays and Sundays that it continually travels in a double line. Consequently, one pair of wheels of each vehicle uses the shoulder of the road. Maintenance of the shoulders consists in adding gravel and disintegrated granite with clay for a binder and dragging in the shoulders about twice a week. The cost of this work has averaged practically $100 per mile. The experience with this section, 10 or 12 ft. of concrete and macadam shoulders, shows it is not a satisfactory design for heavy traffic roads.

**Water-Bound Macadam.**—The oldest section of state highway is local stone water-bound macadam and extends from the Kittery-Portsmouth bridge 8,132 ft. easterly. This section was constructed in 1910 and has been treated annually with Tarvia-B and sand. In 1915 the treatment averaged 1-9 gal. per square yard of surface with occasional patching as indications of surface weakness were discovered. This road carries a traffic which runs as high as 3,000 automobiles some days and it is in a fairly satisfactory condition.

One other section of water-bound macadam was completed in July and was maintained through the balance of the season without any treatment. This latter section will be treated in the spring of 1916.

One other section of water-bound macadam constructed in 1915 will also receive treatment in 1916.

**Gravel Roads.**—Sections of gravel-surfaced road lying on the same route with bituminous macadam and cement concrete were given one treatment with Tarvia-B and sand about the first of June and then patched occasionally through the summer. These sections were in good condition all through the season. The treatment consisted of about ½ gal. of tar per square yard. One-half the road was treated at a time and a day or more elapsed before the tar was applied to the other half of the road.

These same sections received two similar treatments during 1914, the first about June 1 and the second about Aug. 1. In both treatments 6-10 gal. of tar per square yard were used. In the spring of 1915 the tar of course broke up into small scales. The surface was reshaped with a split log drag but not rolled prior to treatment. The treatment was successful and these sections carried a very heavy motor traffic throughout the season.

The cost of maintaining these surfaces, including treatment, patching and patrolling was about $600 per mile for a 16 ft. surface.

## WORK OF U. S. OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING IN 1915.

Over 4,942,000 sq. yd. of roadway, the equivalent of 561.9 miles of road 15 ft. wide, were constructed under the supervision of Federal road engineers during the last fiscal year, according to the annual report of the Office of Public Roads and Rural Engineering, of the U. S. Department of Agriculture, just issued. This is more than double the mileage so constructed in previous years.

The yardage of the different types of surfacings constructed last year were as follows:

| | Sq. yds. |
|---|---|
| Gravel | 1,848,280 |
| Macadam | 1,565,163 |
| Earth | 767,437 |
| Bituminous macadam | 310,643 |
| Sand-clay | 295,337 |
| Concrete | 84,454 |
| Bituminous concrete | 39,813 |
| Surface treatment | 30,835 |

The roads constructed under supervision of the office include experimental roads, post roads, county roads, and roads in National Parks and forests. The expenditures of the office for this purpose were chiefly for engineering services and supervision, the communities, except in the case of forest and park roads, meeting the bulk of the costs for material and construction.

A special appropriation was made for the construction of the post roads in the post office appropriation bill of 1912. Eight of the 11 post road projects remaining at the beginning of the last fiscal year were completed by the end of the year, bringing the mileage of the completed roads under this special project to 397.6. Three of the original 17 projects, aggregating 59.17 miles in length, remained uncompleted at the end of the year. The 8 projects completed are in 7 States and traverse 15 counties.

The office made studies and recommendations for improving the complete road systems of 32 counties in a number of States, assigned engineers to inspect specific roads and advise as to their treatment in 113 communities, and specially assigned 7 engineers to assist State departments of roads and other State agencies dealing with roads and road materials.

The demonstration maintenance work undertaken in 1914 on a through route from Washington to Atlanta was continued during the year, the mileage under supervision increasing from 724 to 876. The cumulative effect of continuous maintenance, says the report, has been demonstrated by the fact that from March 15 to the end of the fiscal year, June 30, 1916, the road was not closed to traffic at any point.

In the National parks and National forests the office supervised construction on approximately 170 miles of road, of which about 70 miles were completed. One of the roads under construction—the Escalante-Winder road in the Powell National Forest, Utah—will open up communication with a settlement in the valley of the upper Colorado River which has heretofore been practically cut off from the rest of the world.

The economic work of gathering road statistics and making studies of traffic, road costs, and benefits was continued by the office. Numerous tests and much research work in regard to road materials were conducted.

The office carried on a number of investigations in regard to irrigation in co-operation with States, agricultural experiment stations, and other agencies, chiefly in the West. Drainage investigations were conducted both in the irrigated and humid regions.

In its rural engineering work the office planned farm water supply systems and sanitary systems, and prepared plans for a southern farmhouse, three farmhouses suited to northern conditions, barns, corncribs, stables, machinery sheds, etc. The office also furnished information in regard to electric lighting and power plants for farm refrigerating systems, heating plants, windmill installations, etc.

## MAINTENANCE COST OF AUTOMOBILES.

The city of Oakland, Cal., established a municipal garage in March, 1913, to care for all machines owned and used by the city, excepting those connected with the police and fire departments. At that time there were 18 machines in service.

The functions of the garage have been increased from mere daily care and minor repairs to the full duties of a repair garage. This has meant the installation of a modern machine shop and an increase in the number of machinists, but it has also resulted in a lower cost per mile in the upkeep of the machines. The garage furnishes the full care of the machines, as washing, oiling, supply of gasoline, ordinary running repairs, thorough overhauling once in each 12 or 18 months, repairing, body building, upholstering, and even making of parts and rebuilding entire cars.

Complete check is kept on the use of all machines by an "In-and-out" register; complete check is kept on the handling of the machines by the "Efficiency Marking System on Auto Drivers"; and segregated cost against each machine gives complete check on operation.

Accurate records on each machine are kept for the double purpose of checking the efficiency of the garage, car and driver, and to serve as a basis for apportioning the cost among the various departments.

Some of the most important figures are as follows:

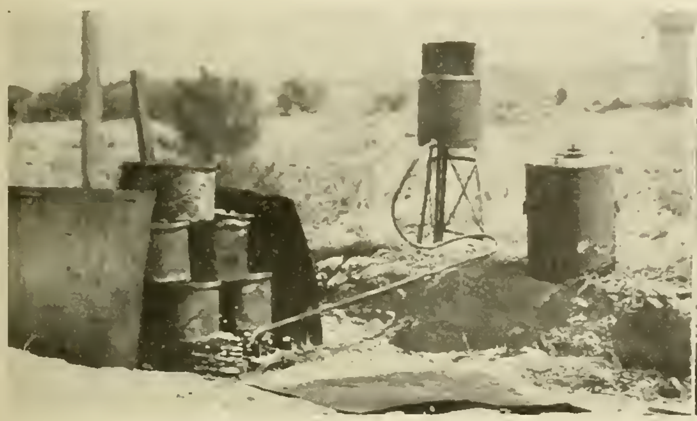
| | 1913-14. | 1914-15. |
|---|---|---|
| Maintenance cost | $17,541.34 | $20,101.78 |
| Number of cars | 35 | 40 |
| Average miles per car | 6,683 | 7,066 |
| Average cost per car | $ 501.17 | $ 502.54 |
| Average cost per mile | $ .075 | $ .071 |
| Average miles per gallon gasoline | | 13 78 |

Comparisons have been made with corresponding costs of cars operated by large public service corporations, and mercantile establishments. Many such concerns do not keep sufficient records to make a comparison possible, but such information as is available indicates that none are operated at a lower cost.

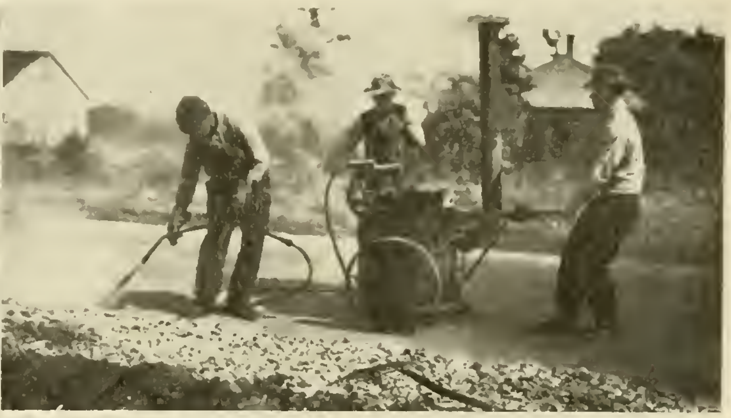
## SMALL HAND OILER FOR MAINTENANCE WORK.

A small hand oiler is used by the Road Department of Los Angeles County. The apparatus forms part of the equipment of the trucks employed on maintenance work on paved ways.

The hand oiler is made of a sheet iron boiler about 2½ ft. in diameter and 3½ ft. long. It has a cast iron pot hanging in the center of the boiler capable of holding 20 gal. of oil. A firebox surrounds the pot which is used sometimes to keep the oil at a certain temperature. The boiler is supported between two iron wheels and is so balanced that the center of gravity is below the axles, thereby always keeping the pot in an upright position. There is a handle on one side of the boiler, which is used to move the machine from one place to another. On the opposite side and on top of the boiler the hand crank for the oil pump is located.



Heating Oil in Buckets with Special Burner.



Hand Oiler of Los Angeles County.

The oil pump is the most important part of the little heater and is fastened to the bottom of the oil pot. The pump is a rotary pump and is driven by a sprocket and chain which runs to the sprocket on the hand crank located on the top of the boiler. This pump is capable of a pressure of from 6 to 10 lb. The pump is connected with a 20-ft. metallic ¾-in. hose, with a 3½-ft. piece of ¾-in. pipe at the discharge end. The pipe is plugged up with a plug having a slot cut in it so that the oil discharges in a spray. The pipe also has a throttle for turning on or shutting off the oil.

The oil used in the heater is hauled to the various warehouses when hot and is put into 4-gal. pressed steel buckets. The oil cools very quickly and is cold when it is loaded on the maintenance trucks to be taken to the job. When the oil arrives at its destination, the buckets are placed in two long rows on the ground, one upon the other, so that a fire may be built between the buckets and the oil heated to the necessary temperature. Up to about two months ago wood was used to heat the oil, but at the present time the oil is heated by a distillate and water burner invented by one of the foremen of paved ways gang. The burner occupies very little room and oil is easily heated in 15 minutes to 500° F. during rain or shine. The burner is especially efficient in winter, as it does away with using wet wood for a fire.

With this new heater about 80 buckets of oil may be heated at one time. When the oil is heated to between 400 and 500° F. about 15 to 20 gal. are poured into the hand oiler. One man pushes the oiler to the spot to be repaired, another works the pump and a third man does the spraying of the oil.

On street oiling as much as 125 gal. per hour may be applied. The best results may be obtained from this hand oiler by heating the oil to about 500°. By heating the oil to the above temperature, it is not necessary to maintain a fire in the hand oiler. A fire in the hand oiler often proves very injurious to the oil pump, as it causes a coating of oil cake to form in the bottom and sides of the pot. This in turn will get into and clog up the pump.

A man, after handling the spraying nozzle, can apply any specified amount of oil to the square yard very accurately. This hand oiling machine, after castings are made, is assembled at the mechanical shop of the county.

F. H. Joyner is Road Commissioner of Los Angeles County.

## MOTOR TRUCK TRAFFIC ON NEW YORK HIGHWAYS.

During 1915 the State Commissioner of Highways of New York made a careful study of the amount of use to which the State and county highways were subjected by motor trucks and motor busses. The results of this census are given in the recently issued annual report of the Commissioner.

It was found that the trucks and buses ran from 1 ton to 15 tons weight, including the vehicle. By far the larger number consisted of 3-ton trucks. The reports thus obtained as to each truck and bus upon an estimated yearly period of 40 weeks (eliminating the entire 12 weeks during the winter season) show that the traffic upon improved State and county highways from motor buses and motor trucks amounts to 14,734,680 miles for the 40 weeks, having 60,216,520 ton-mileage. The following figures show the mileage and average speed for the various sizes of trucks:

| Total load per truck in tons. | Total mileage for the state per year of 40 weeks. | Average speed. |
|---|---|---|
| 1 | 565,680 | 19.4 |
| 1½ | 858,720 | 17.4 |
| 2 | 1,609,680 | 17.1 |
| 2½ | 1,520,080 | 17.7 |
| 3 | 2,217,880 | 16.5 |
| 3½ | 1,039,920 | 14.6 |
| 4 | 1,803,840 | 14.6 |
| 4½ | 503,680 | 14.2 |
| 5 | 1,005,400 | 13.9 |
| 5½ | 176,760 | 12.3 |
| 6 | 652,640 | 13.2 |
| 6½ | 267,880 | 11.9 |
| 7 | 633,960 | 13.2 |
| 7½ | 132,880 | 13.6 |
| 8 | 681,160 | 12.7 |
| 8½ | 24,400 | 11.3 |
| 9 | 390,080 | 12.9 |
| 10 | 529,280 | 13.3 |
| 11 | 8,880 | 11.7 |
| 11½ | 8,640 | 10.0 |
| 12 | 59,320 | 12.1 |
| 13 | 4,640 | 10.0 |
| 14 | 4,640 | 10.0 |
| 15 | 4,640 | 10.0 |
| Total | 14,734,680 | |

## THE NEW ORGANIZATION OF THE U. S. OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING.

On Nov. 1 the new organization of the Office of Public Roads and Rural Engineering of the U. S. Department of Agriculture went into effect. Under this plan there are two main branches (1) Engineering and (2) Management and Economics. The chief engineer has charge of the Engineering Branch. He reports to the director, and in the absence of the Director he becomes the Acting Director.

The Chief of Managament has charge of the Management and Economics Branch, reporting to the Director, and in the absence of both the Director and the Chief Engineer becomes the Acting Director. The General Inspectors inspect field operations upon instructions from the Director, and report thereon to the Director.

No change can be made in work in progress, nor can any new work be undertaken by employes in either branch, except by direction of the chief of the branch involved. No employe will conduct, except through his immediate superior, any official business with other employes. Instructions to the Chief Engineer and the Chief of Management will be given only by the Director or by the Acting Director.

Should the Director find it necessary to make a suggestion or give instructions to any employe of either branch, such employe will forthwith give to his immediate superior a written memorandum covering the suggestions or instructions, which memorandum will be submitted promptly, through the proper channels, to the chief of the branch in which he is employed. This restriction does not apply to General Inspectors.

The organization is shown by the chart. It will be noted that the highway construction and maintenance division is divided into 10 field districts. Each of these is in charge of a district engineer who reports directly to the Chief Engineer.

Thus far the engineers assigned to the respective districts are as follows:

First District—L. I. Hewes.
Second District—C. H. Sweetser.
Third District—J. A. Whittaker.
Fourth District—E. O. Hathaway.
Fifth District—J. C. Wonders.
Sixth District—J. D. Fauntleroy.
Seventh District—J. T. Voshell.
Eighth District—J. T. Bullen.
Ninth District—G. H. Miller.
Tenth District—H. K. Bishop.

The duties of the Engineering Branch comprises the following:

(1) Road Construction and Maintenance; (2) Road Material Test and Research; (3) Farm Irrigation Investigation; (4) Farm Drainage Investigations; (5) Rural Engineering. Road Construction and Maintenance comprises (1) Road Construction and Maintenance Investigations Authorized in the Agricultural Appropriation Act, and (2) Federal Aid Road Construction and Maintenance. The first mentioned comprises (1) Supervision of Object Lesson Road and Bridge Construction; (2) Co-operative Road Maintenance; (3) Maintenance of Experimental Roads, and (4) Inspection and Advice concerning various Field Problems of Road and Bridge Construction and Maintenance. Federal Aid Road Construction and Maintenance comprises (1) Post Road Construction under the Federal Aid Road Act, and (2) Surveys, Inspection, Construction, and Maintenance of Forest Roads under Section 8 of the Federal Aid Road Act.

The District Engineering Work comprises (1) All engineering work assigned to it by the Chief Engineer, including Federal Aid Roads, object-lesson roads, experimental roads, advice to state and county officials; (2) All surveying, inspection and supervision of construction and maintenance work under Section 8 of the Federal Aid Road Act in the National Forests in collaboration with the Forester; (3) Such studies of road economics, made at the request of the Chief of Management, as are assigned to the district by the Chief Engineer, and (4) Such other duties as may from time to time be assigned by the Chief Engineer.

Road Material Tests and Research comprises investigations, reports, and advice upon (1) the chemical and physical character of road materials; (2) classification of rocks according to their mineral constituents; (3) standardization of methods of testing bituminous and non-bituminous road materials; (4) occurrence manufacture, and properties of dust preventives and road binders; (5) non-bituminous road materials; (6) the use of concrete for road and bridge purposes, and (7) the making of field experiments.

Farm Irrigation Investigation comprises investigations, reports, and advice upon (1) the utilization of water in irrigation; (2) kinds of power and appliances for irrigation; (3) the development of irrigation equipment; (4) the flow of water in ditches, pipes, etc.; (5) the duty, apportionment and measurement of water; (6) customs, regulations and laws relating to irrigation, and (7) the drainage of irrigated lands.

Farm Drainage Investigations comprises investigations, reports and advice upon (1) farm drainage; (2) the drainage of swamps and wet lands; (3) the removal

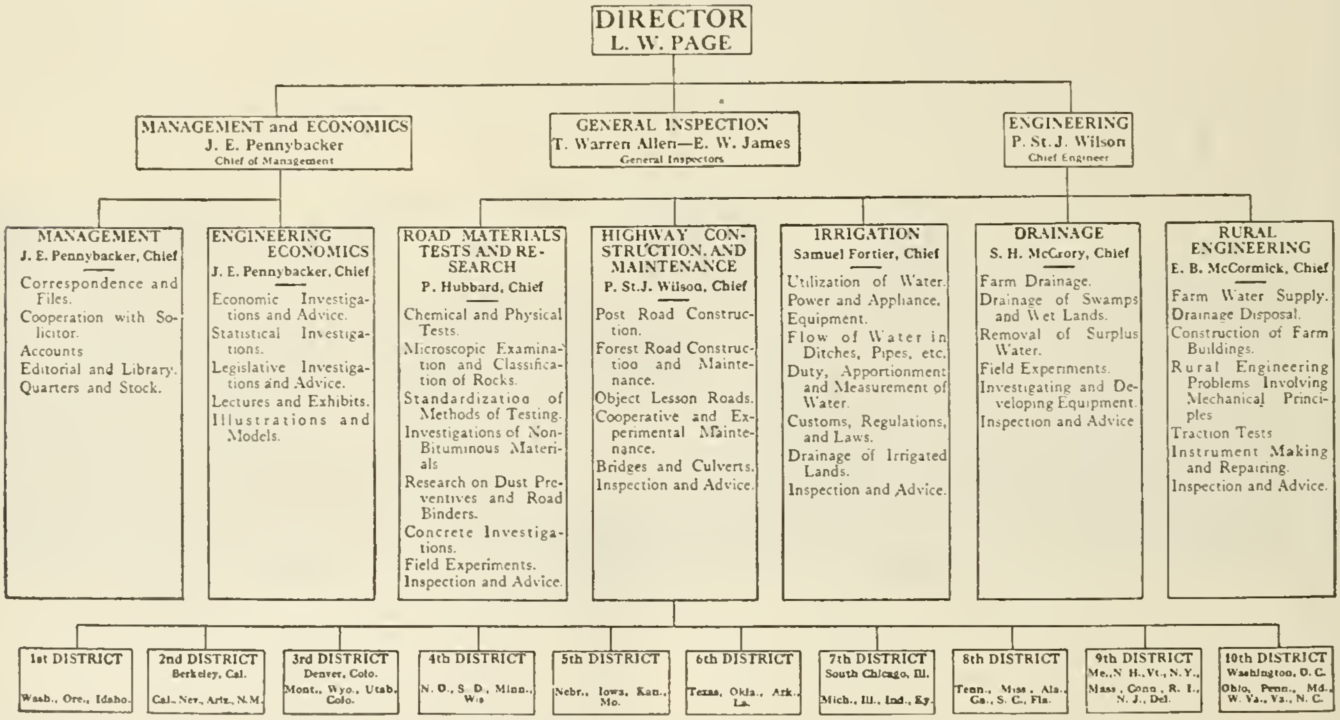

DIRECTOR
L. W. PAGE
MANAGEMENT and ECONOMICS
J. E. Pennybacker
Chief of Management
GENERAL INSPECTION
T. Warren Allen—E. W. James
General Inspectors
ENGINEERING
P. St. J. Wilson
Chief Engineer
MANAGEMENT
J. E. Pennybacker, Chief
Correspondence and Files.
Cooperation with Solicitor.
Accounts
Editorial and Library.
Quarters and Stock.
ENGINEERING ECONOMICS
J. E. Pennybacker, Chief
Economic Investigations and Advice.
Statistical Investigations.
Legislative Investigations and Advice.
Lectures and Exhibits.
Illustrations and Models.
ROAD MATERIALS TESTS AND RESEARCH
P. Hubbard, Chief
Chemical and Physical Tests.
Microscopic Examination and Classification of Rocks.
Standardization of Methods of Testing.
Investigations of Non-Bituminous Materials
Research on Dust Preventives and Road Binders.
Concrete Investigations.
Field Experiments.
Inspection and Advice.
HIGHWAY CONSTRUCTION AND MAINTENANCE
P. St. J. Wilson, Chief
Post Road Construction.
Forest Road Construction and Maintenance.
Object Lesson Roads.
Cooperative and Experimental Maintenance.
Bridges and Culverts.
Inspection and Advice.
IRRIGATION
Samuel Fortier, Chief
Utilization of Water.
Power and Appliance, Equipment.
Flow of Water in Ditches, Pipes, etc.
Duty, Apportionment and Measurement of Water.
Customs, Regulations, and Laws.
Drainage of Irrigated Lands.
Inspection and Advice.
DRAINAGE
S. H. McCrory, Chief
Farm Drainage.
Drainage of Swamps and Wet Lands.
Removal of Surplus Water.
Field Experiments.
Investigating and Developing Equipment.
Inspection and Advice
RURAL ENGINEERING
E. B. McCormick, Chief
Farm Water Supply.
Drainage Disposal.
Construction of Farm Buildings.
Rural Engineering Problems Involving Mechanical Principles
Traction Tests
Instrument Making and Repairing.
Inspection and Advice.
1st DISTRICT
Wash., Ore., Idaho.
2nd DISTRICT
Berkeley, Cal.
Cal., Nev., Ariz., N. M.
3rd DISTRICT
Denver, Colo.
Mont., Wyo., Utah, Colo.
4th DISTRICT
N. D., S. D., Minn., Wis.
5th DISTRICT
Nebr., Iowa, Kan., Mo.
6th DISTRICT
Texas, Okla., Ark., La.
7th DISTRICT
South Chicago, Ill.
Mich., Ill., Ind., Ky.
8th DISTRICT
Tenn., Miss., Ala., Ga., S. C., Fla.
9th DISTRICT
Me., N. H., Vt., N. Y., Mass., Conn., R. I., N. J., Del.
10th DISTRICT
Washington, D. C.
Ohio, Penn., Md., W. Va., Va., N. C.

Chart of New Organization of U. S. Office of Public Roads and Rural Engineering.

of surplus water; (4) the development of drainage equipment, and (5) the making of field experiments.

Rural Engineer comprises investigations, reports, and advice upon (1) farm domestic water supplies; (2) drainage disposal; (3) construction of farm buildings; (4) rural engineering problems involving mechanical principles; (5) traction tests on highways, and (6) construction and repair of instruments used in investigative work.

## COMPARATIVE ANALYSIS OF ECONOMIC EFFECT OF ROAD IMPROVEMENTS IN EIGHT COUNTIES.

In order to obtain direct information as to the benefits and burdens imposed upon communities through the construction of systems of improved roads, the U. S. Office of Public Roads, decided in 1909 to make a series of exhaustive studies in selected counties. These studies were designed to cover a period of approximately 5 years, or a sufficient period to show the road improvement from its inception until such time as the full measure of its usefulness could be demonstrated. The counties selected were Spottsylvania, Dinwiddie, Lee and Wise in Virginia; Franklin in New York; Dallas in Alabama; Lauderdale in Mississippi, and Manatee in Florida. These counties had recently voted bonds for the construction of improved roads and it therefore was possible to make a series of studies to cover the road improvement from the outset to completion.

The information assembled during the years 1910 to 1915 regarding the work in these counties has been published in a bulletin issued last month by the U. S. Department of Agriculture. The bulletin was prepared by J. E. Pennybacker, Chief of Road Economics, and Mr. O. Eldridge, Assistant in Road Economics, of the U. S. Office of Public Roads. A comparative analysis of the more striking data obtained in the respective studies is given below:

### Character of Bonds Issued.

In some of the counties comprised in the economic studies bonds were issued on the sinking-fund plan, and in others the serial method was followed. Analysis of the methods followed in each case brings out some interesting points. Spottsylvania County, Va., issued $173,000 of 4.5 and 5 per cent bonds payable in 30 years, and callable after 5 years. It is impossible to estimate the total cost of retirement owing to the element of variability in the rate of retirement under this arrangement. In Dallas County, Ala., the bonds amounted to $350,000, payable in 30 years at 5 per cent. Assuming the sinking fund to bear 3 per cent interest the total financial burden to the county for interest and the liquidation of the bonds during the 30-year period will be $745,702. That the method of financing the road improvement chosen by Dallas County is not as economical as might have been selected is indicated by the fact that an equal amount of bonds at the same rate of interest, if issued under the deferred serial bond method, with the first bonds payable 6 years from the date of issuance and an equal amount payable each year thereafter for 24 years, would cost the county at the end of the 30 years $665,000, or a difference, as compared with the sinking-fund method, of $80,702. If 4 per cent could be realized on the sinking fund instead of 3 per cent, the saving for the deferred serial plan over the sinking-fund plan would still be $47,216.

In the case of Manatee County, Fla., the bond issues aggregate $250,000 and run 30 years at 5 per cent. As in this case the sinking fund also yields 5 per cent interest, the method of bonding is reasonably economical on the present basis. It is doubtful, however, if the sinking fund will continue to bring such an unusual return, and as soon as a lesser rate of interest is obtained or any of the sinking fund is not promptly invested, the sinking-fund method will become more costly than the serial method which might have been adopted.

Lee County, Va., adopted the deferred serial method, and had its bonds run from the 5th year to the 26th year. This is the only one among the entire eight which appears to have adopted the most prudent and economical method of handling the bond issue.

In Wise County the $960,000 of 5 per cent bonds were issued for 30 years, with a 20-year redemption clause. Assuming that the bonds are retired the 25th year on the sinking-fund plan, with interest on sinking fund bearing 3 per cent, the total outlay would be $1,858,269. If Wise County had adopted the serial method with its serial payments beginning with the 6th year and ending the 25th year, the total cost would be $1,704,000, a saving for the serial plan over the sinking-fund plan of $154,269. If 4 per cent could be realized on the sinking fund, the saving would still be $72,288.

Dinwiddie County, Va., issued $105,000 of 5 and 6 per cent bonds, payable in 30 years, but the bonds are callable after 20 years. Assuming that they will be retired at the end of 25 years on the sinking-fund plan, with interest on sinking fund at 4 per cent, the total cost would be $218,031, whereas if they had adopted the 6-25 year serial method the cost would be $201,100, or a difference of $16,931.

Franklin County, N. Y., is operating at a disadvantage, as its first serial payment is not made until the 10th year. This county also has followed the rather dangerous method of extending its date of payment over a long period of years, with the result that the indebtedness long outlines the estimated life of the improvements made. The bonds, amounting to $500,000 at 5 per cent, run from 10 to 50 years under the deferred serial method.

Lauderdale County, Miss., which issued $500,000 of 5 and 5½ per cent bonds, adopted the deferred serial-bond method, with the first payment coming 11 years from the date of issue and the last payment 25 years. If the county had issued the bonds on the 6-25 year basis the cost would have been $906,875, as compared with the cost on the basis adopted of $972,232, or a difference of $65,367.

It would seem that the most economical form of bond to issue is the deferred serial with the first payment at the end of the 6th year and the payments then extending to a final term varying in length according to local conditions, but never exceeding 30 years. By having the first payment deferred to the 6th year the county has an opportunity to complete its road system and enjoy the benefits before beginning payment, but if the deferred period is much greater all of the evils of the sinking-fund plan with no corresponding merits are adopted. If local communities throughout the United States could profit by these examples the result would be the saving of many millions of dollars.

In one of the counties it was found that an amount probably aggregating as much as $5,000 had been lost to the county through a premature sale of the bonds; that is, in selling the bonds before the funds actually were needed. This resulted in the payment of interest much in excess of that which could be obtained upon cash balances in bank. Counties should pay due regard to this feature of road finance, even though the necessary precautions would save only a small amount.

### Management of the Improvements.

In the eight counties selected several forms of management were in effect and a noticeable tendency was demonstrated on the part of county authorities to select and designate for improvement a larger mileage of roads than the funds contemplated were adequate to construct. This was especially true in those counties where a considerable amount of grading was involved and where comparatively expensive types of construction were contemplated. Naturally these faulty estimates resulted in dissatisfaction and distruct among the taxpayers and to require either additional heavy outlays or the leaving of the project in a partially completed state. Judging from these examples, it is quite obviously essential that where any county contemplates comprehensive improvements involving large outlays and expensive types of construction, the detailed advice and estimate of a competent highway engineer be secured before the people are asked to approve the bond issue. In the case of the four Virginia counties the actual work of constructing the roads after the bonds were voted was under the control of the state highway department, and it appears that excellent results were obtained commensurate with the outlay of funds; but the Virginia law was evidently defective in that no provision was made for a competent authority to make estimates and to give advice preliminary to the issuance of bonds. The Virginia Legislature has since, at its 1916 session, enacted legislation covering this point. The experience of the counties covered by these studies indicates the wisdom of a statute in each state requiring a reliable estimate upon which bond elections should be based.

The road construction in these counties would seem to bear out the assertion which has often been made that from 20 to 25 per cent of the total road mileage of a county, if wisely distributed, will service traffic needs to the extent of at least 80 or 85 per cent of the total. In one of the counties included in these studies it will be noted that the mileage is excessively large in comparison with the ton-mileage hauled over the improved roads. In this case it would seem that the county has overbuilt its improved-road system and that a lesser mileage would have served its traffic needs.

A question partly of management and partly of finance is involved in the experience of the eight counties in regard to road maintenance. In the study of these eight counties it was found that Franklin County, N. Y., and Lauderdale County, Miss., were most effectively meeting the problem of maintenance. In the case of Franklin County the state was directly concerned in the maintenance of the roads and had complete control over such work on some of the roads and an indirect control over other roads, thus applying to the task a skilled management, the details of which are explained in the chapter on Franklin County. In Lauderdale County, Mississippi, the work is conducted under an excellent provision of law which specifies that an amount of not less than 1 mill on the dollar shall be levied to provide a maintenance fund for all of the roads constructed by means of bond issues, and this fund is to be kept separate from all other county funds and can be used only for maintenance. As a result of this law the Lauderdale County roads are not only in as good condition today as when completed, but have been actually improved. Thus the county's investment in good roads has not been allowed to deteriorate in the slightest degree.

The 1916 Virginia Legislature has met the maintenance situation by providing that an annual tax of not less than 3 per cent of the amount of bonds issued shall be levied to provide a maintenance fund. A conspicuous example of an emergency situation with reference to road maintenance is afforded by Spotsylvania County, where no provision was made for maintenance of the bond-built roads. It was found that rapid deterioration was taking place and that insufficient funds existed with which to meet the situation. Accordingly toll gates were established on the principal roads and a sufficient revenue was derived from this source, not only to maintain the roads, but to actually extend the construction a short distance. This reversion to a system long since abolished by most countries is partly due to the Virginia administrative and fiscal organization, under which the cities of the State are not taxed for county purposes (although they may aid in the improvement of roads for a distance of 10 miles from the city limits if the City Council so elects). Thus it came about that while the city of Fredericksburg, in Spotsylvania County, contributed no part of the financial burden of maintaining the roads, it was, because of the heavy automobile traffic emanating from that point, a very destructive element to the county road system. In view of the very rapid development of motor vehicles during the past decade and the prospects of much more widespread use of this means of transportation in the future, the desirability of making provisions so that the cities may aid in the construction and maintenance of roads in the surrounding territory.

As to the quality of supervision, it would seem that there is little room for criticism in any of the eight counties. The work in the four Virginia counties was directed by a resident engineer from the State highway department, while the work in Dallas, Lauderdale, and Manatee Counties was all directed by special highway commissions, who, without exception, selected competent engineers and accomplished most commendable results. Franklin County, New York, was fortunate in having for the direction of its work a competent county superintendent, who possessed all of the practical and technical qualifications for the successful management of the work.

### Economic Benefits to the Respective Counties.

In arriving at an estimate of the benefits which a county receives through the improvement of its public roads, certain factors must be taken into account more as the media by which the benefits may be measured than as the actual benefits themselves. While it is realized that the increase in the value of land must not be added to the saving in hauling costs, the convenience and access to schools, markets, churches, etc., but is rather the effect produced by those causes, it is perhaps the best index which can be obtained as to the economic value of the roads to the community. A study of the increase in the values of farm lands in the eight counties reveals the rather interesting fact that following the improvement of the main market roads the increase in the selling price of tillable farm lands served by the roads has amounted to from one to three times the total cost of the improvements. The increase in values in those instances which were recorded ranged from 63 per cent to 80 per cent in Spotsylvania, from 68 to 194 in Dinwiddie, 70 to 80 in Lee, 25 to 100 in Wise, 9 to 114 in Franklin, 50 to 100 in Dallas, 25 to 50 in Lauderdale, and from 50 to 100 in Manatee. The estimates of increase were based for the most part upon the territory within a distance of one mile on each side of the roads improved. These estimates are not claimed to be mathematically exact, but it is believed that they will give a fairly accurate indication of the results which may be expected under similar conditions.

In dealing with the effect of road improvement upon

TABLE I.—APPROXIMATE SAVING IN HAULING COSTS ON PRESENT TONNAGE BASIS AFTER DEDUCTING ANNUAL COST OF IMPROVEMENTS DURING PERIOD COVERED BY BONDS.

[Averages are weighted.]

| Selected counties. | Bonds issued. | Value of state-aid contributions in convict labor. | Estimated annual outlay for interest and retirement of principal.[1] | Annual ton-miles of traffic. | Annual cost of principal and interest and convict-labor aid per ton-mile of traffic. | Hauling cost per ton-mile. Before improvement. | Hauling cost per ton-mile. After improvement. | Gross saving per ton-mile. | Saving per ton-mile after deducting cost of interest and principal.[1] |
|---|---|---|---|---|---|---|---|---|---|
| Spotsylvania, Va. | [2]$ 110,000 | $11,856.41 | $ 10,533.00 | 921,521 | $0.0114 | $0.300 | $0.137 | $0.163 | $0.149 |
| Dinwiddie, Va. | 105,000 | 37,038.32 | 10,573.65 | 833,136 | .0126 | .300 | .150 | .150 | .137 |
| Lee, Va. | 455,000 | 21,175.48 | 27,967.34 | 297,180 | .0941 | .400 | .200 | .200 | .106 |
| Wise, Va. | 960,000 | ......... | 74,330.00 | 200,000 | .3716 | .570 | .230 | .340 | —.032 |
| Franklin, N. Y. | 500,000 | ......... | 21,730.00 | 242,145 | .0897 | .303 | .096 | .207 | 117 |
| Dallas, Ala. | 350,000 | ......... | 24,856.76 | 610,000 | .0407 | .300 | .150 | .150 | .109 |
| Lauderdale, Miss. | 500,000 | ......... | 33,466.66 | 255,378 | .1310 | .370 | .200 | .170 | .039 |
| Manatee, Fla. | 250,000 | ......... | 16,262.85 | 130,292 | .1247 | .450 | .200 | .250 | .125 |
| Total and average | $3,260,000 | $70,070.21 | $219,720.26 | 3,489,652 | $0.0629 | $0.335 | $0.157 | $0.179 | $0.116 |

[1] Plus interest at 5 per cent on value of state-aid contributions of convict labor. [2] Exclusive of $33,000 voted but not yet issued for Livingston and Berkley districts.

the hauling of commodities, the method has been adopted of ascertaining the traffic area served by each road much in the same manner as the drainage area of a stream is ascertained. After determining such areas the character and amount of production is ascertained and an estimate is made as to the proportion of the tonnage produced which is hauled upon the roads. A further investigation is made as to shipments by rail in and out of the county and information is obtained from United States census reports and from merchants and producers to verify the results obtained from the traffic-area calculation and the freight-tonnage inquiry. In some cases an actual traffic count or census is taken to determine the tonnage hauled upon the roads. From these various sources it is possible to arrive at a reasonably accurate estimate of the tonnage hauled over the improved roads. It is a comparatively easy matter to determine the average length of haul in each case and the prevailing rate of wages for men and teams. With these factors the total tonnage, the total ton-mileage, and the cost per ton-mile before and after the improvement of the roads are computed. The saving to traffic represented by the road improvement is thus expressed in dollars. It is of course realized that the figures given do not represent an actual "dollars and cents" saving, as many of the men and teams figured in on a wage basis might have been idle if they had not been engaged in hauling the products of farm and forest. But they at least indicate the saving in time and energy, and these have a monetary value. Therefore the saving to traffic in each county is stated for the purpose of indicating to the readers of this bulletin a relative figure by which they can determine the waste due to a system of poor roads. Considering the eight counties in the aggregate, the gross annual saving in hauling costs due to their good-roads systems affords the rather impressive total of $627,409 for a traffic of 3,489,652 ton-miles. The average gross saving per ton-mile for the eight counties is 17.8 ct., this being indicated by an average rate of 33.5 ct. before the roads were improved, as compared with 15.7 ct. after the roads were improved.

In order to determine the net saving on a ton-milage basis, it is necessary to deduct from the gross saving the estimated annual outlay for interest and retirement of the bonds and for interest on the value of aid received from the State or from any source other than the bond issue. Table I gives not only the gross saving per ton-mile, but also the net saving after taking into account the cost of the improvements on this basis. It should be borne in mind that the estimated annual outlay for interest and retirement of principal may not conform strictly to the practice which may be followed in the respective counties, as instead of levying the amount which would be mathematically correct for this purpose, they may raise an unnecessarily large amount or an utterly inadequate amount from year to year. The table is based upon the amounts they should levy each year to retire the bonds under the plan by which the bonds were issued. The annual cost of maintenance should be considered as a partial offset to the saving in hauling costs if the outlay for maintenance is greater after the roads are improved than before improvement. That the cost is greater after improvement can scarcely be doubted, as real maintenance was scarcely in effect at all before the roads were improved. Definite cost data on maintenance of a comparative value for all the counties are lacking, and are, therefore, not taken into account in the table.

A comparison of the effect of the road improvement upon country schools affords probably a more complete vindication of the outlay than even the material features which have been presented. Combining the results obtained in all of the eight counties, it appears that before the roads were improved the average school attendance was 66 pupils of each 100 enrolled, as compared with 76 after the roads were improved. A consideration of this showing must reveal the fact that the good roads have been materially responsible for the education of 10 children out of each hundred. Not only have the roads contributed toward a larger school attendance, but they have been quite instrumental in lifting the standard of instruction by making easier the consolidation of little one-room schools into graded schools. In Dinwiddie County the system of taking the children to and from school by means of wagons has been adopted since the roads were improved.

Taking it from all of these angles, the experience of the eight counties has demonstrated that the beneficial effects of the road improvement justified the outlay, and that while more efficiency and economy might have been obtained in some cases, the loss was not such as to make the citizens of any of the counties feel that the move for better roads had been an unwise one.

TABLE II.—ROAD MILEAGE.

| State and county. | Total of all roads. | Miles of road per square mile of area. | Surfaced— Under bond issue, miles. | Surfaced— Total, miles. | Graded under bond issue, miles. | Total graded or surfaced, miles. |
|---|---|---|---|---|---|---|
| Virginia: | | | | | | |
| Spotsylvania | 400 | 0.97 | [1]76.73 | 82.73 | ..... | 82.73 |
| Dinwiddie | 524 | 1.01 | [2]91.3 | 101.06 | ..... | 101.06 |
| Lee | 450 | 1.00 | [1]39.26 | 44.86 | [1]60.19 | 105.05 |
| Wise | 300 | .71 | 78.47 | 83.07 | 62.75 | 145.82 |
| New York, Franklin | 1,370 | .82 | 124.0 | 386.8 | ..... | 368.8 |
| Alabama, Dallas | 1,000 | 1.04 | 101.75 | 217.9 | ..... | 217.9 |
| Mississippi, Lauderdale | 800 | 1.16 | 93.75 | 146.75 | ..... | 146.75 |
| Florida, Manatee | 575 | .43 | 57.25 | 57.25 | 6.4 | 63.65 |

[1]Built partly with state convicts. [2]Built entirely with state convicts.

TABLE III.—ROAD MILEAGE—CHARACTER AND COST.

| State and county. | Road mileage (per cent of grand total.) Surfaced only. | Graded only. | Graded or surfaced. | Character of surface. | Cost per mile. |
|---|---|---|---|---|---|
| Virginia: | | | | | |
| Spotsylvania | 20.6 | .... | 20.6 | Sand-clay<br>Gravel | [1]$1,150-$1,500<br>[1]2,000- 2,500 |
| Dinwiddie | 19.3 | .... | 19.3 | Gravel, sand-clay, top-soil | 1,300- 1,700 |
| Lee | 10.0 | 13.3 | 23.3 | Earth<br>Macadam | [1]3,000- 3,500<br>[1]6,000- 7,000 |
| Wise | 27.7 | 20.9 | 48.6 | Earth<br>Macadam<br>Bituminous surface treatment | 5,700<br>9,200<br>400 |
| New York, Franklin | 28.2 | .... | 28.2 | Gravel<br>Macadam | 1,900- 2,500<br>3,000- 4,000 |
| Alabama, Dallas | 21.7 | .... | 21.7 | Gravel<br>Sand-clay | 3,000- 3,600<br>1,500- 1,800 |
| Mississippi, Lauderdale | 18.3 | .... | 18.3 | Gravel-macadam<br>Sand-clay | 4,000- 6,000<br>1,700- 2,000 |
| Florida, Manatee | 9.9 | 1.1 | 11.0 | Marl-rock macadam<br>Flint-rock macadam<br>Shells | 3,800<br>4,700<br>2,400 |

TABLE IV.—ROAD BONDS AND TAXATION DATA.

| State and county. | Bonded debt incurred for roads. Total to to 1915, inclusive. | Per capita. | Per $100 assessed valuation (1915). | Term of bonds in years. | Interest rate on bonds, per cent. | Average rate of tax per $100 of assessed valuation. —All purposes— 1910. | 1915. | —Road bonds— 1910. | 1915. |
|---|---|---|---|---|---|---|---|---|---|
| Virginia: | | | | | | | | | |
| Spotsylvania | [1]$173,000 | $10.93 | $4.97 | 25-30 | 4½-5 | $1.20 | $1.70 | [3]$0.45 | $0.625 |
| Dinwiddie | 10[illegible],000 | 2.66 | 1.75 | [4]20-30 | 5 -6 | 1.20 | 1.20 | ..... | .10 |
| Lee | 455,000 | 19.08 | 9.15 | 25-26 | 5½ | 1.40 | 1.96 | ..... | .61 |
| Wise | 960,000 | 28.10 | 7.04 | [4]20-30 | 5 | 1.40 | 1.762 | 0.30 | .562 |
| New York, Franklin | 700,000 | 10.92 | 3.66 | [5]10-50 | 4½-5 | ([6]) | ([6]) | ([6]) | ([6]) |
| Alabama, Dallas | 370,000 | 6.57 | 2.48 | [7]30 | 5 | 1.35 | 1.40 | ..... | [8].176 |
| Mississippi, Lauderdale | 500,000 | 10.65 | 3.08 | [5]10-25 | 5 -5½ | 1.54 | 1.66 | ..... | .16 |
| Florida, Manatee | 250,000 | 26.17 | 3.09 | [7]30 | 5 | 2.65 | 2.60 | .70 | .30 |

[1]Amount authorized but only $140,000 sold. [2]Callable after 5 years. [3]Average for two districts only. [4]Deferred serial with sinking-fund provision. [5]Deferred serial. [6]Taxes levied by towns and vary in each. [7]Sinking fund. [8]No special levy made for road bonds, but an average rate of 17.6 cents on the $100 will pay interest and create sinking fund with which to retire bonds in 30 years.

## METHOD AND COST OF GROUTING BRICK PAVEMENTS.

The Illinois State Highway Department has particularly specific requirements for grouting of the brack pavements in State highway work. These instructions are given in the standard specifications as follows:

> The cement grout used in filling the joints in the brick surface shall consist of 1 part by volume of Portland cement and 1 part sand, the materials to be of the character specified herein. The sand and the cement shall be first mixed dry in a suitable box. After the sand and cement have been mixed dry to a uniform color, water shall be added slowly and the mixing continued until the mortar is uniform and of a consistency thinner than thin cream. During the spreading of the mortar on the pavement surface, the mortar in the box shall be constantly stirred and shall be deposited on the brick by means of scoop shovels. Before the cement grout is spread, the brick surface shall be thoroughly wetted. Mortar shall then be poured on the surface from the scoop shovels and immediately brushed into the openings between the brick with a coarse rattan broom, the broom being worked across the rows of brick in a diagonal direction. The operation of filling the joints shall be carried along continuously until about 200 feet of the roadway has been treated. The gang shall then be taken back to the point of starting and the surface gone over a second time in the same manner, except that the consistency of the mortar shall be somewhat thicker than that which was used for the first filling of the joints, and except also that a squegee shall be substituted for the coarse rattan broom for brushing the mortar into the openings between the brick. As many different applications of the mortar shall be made as are deemed necessary, in order to fill completely the opening between the bricks, and each successive application after the first one shall be attended by the use of the squegee instead of the rattan broom. When completed, there shall be practically no excess mortar on the surface of the brick, but all joints shall be filled flush with the surface of the pavement. As soon as the joints have been filled the second time, the surface shall be inspected, and if approved shall be covered with sand and kept wet for ten days, and the contractor shall permit no traffic on the roadway for 3 weeks. The grout filler shall not be applied during freezing weather, and if freezzing weather occurs within one week after the filler is applied, the contractor shall permit no traffic on the roadway until authorized by the engineer to do so. The entire operation of grouting the bricks shall be carried on in longitudinal sections of the road. While being grouted, each section of the pavement is to be separated from the immediately adjacent section by tin headers being placed between two adjacent courses of brick and extending entirely across the width of the pavement. These tin headers shall be effective to the end that the grouting of the bricks in any particular section shall be ended against a vertical plane.

Further details regarding the Illinois procedure in applying the grout have been furnished us by Mr. H. E. Bilger, Road Engineer of the State Highway Department.

The all-important matter in the entire process of grouting is to make sure that the grout extends entirely to the bottom of the brick. When a sand cushion is used for the brick, this is practically impossible, inasmuch as after the brick are rolled, there will be at least ½ in. of sand come up between them, so it would probably be better to say that when the sand cushion is used, the first essential to secure a first class job in grouting is to see that the sand is not rolled up between the brick more than ½ in. Having rolled the brick and kept the sand cushion down to the permissible limit, the first application of grout should extend entirely to the bottom of the brick. In order to insure this, it is necessary that the first application be mixed exceedingly thin; in fact, practically the only difference between it and water is the color. If the first application is kept thin and the grout is kept stirred continually while it is being scooped from the box, it will approach as nearly as possible what might be called "fool proof" work. It will be thin enough to go to the bottom of the brick of its own accord, filling up not only all the cross joints between the brick, but also the joints at the ends as well.

Some people have made objection to the swelled ends on certain types of bricks, but if the first application of grout is properly mixed, there is practically no chance whatever for either the end joints or the side joints to escape being completely filled.

In mixing this thin mortar, there should not be added a great deal of water at first, but just enough to make a thin mixture. While it is being thoroughly mixed, more water is gradually added until it is thinned down to the proper consistency. If all the water is added at one time, it makes it exceedingly hard to keep the sand and the cement from separating in the box. It would appear that the best box for this purpose is the one recommended by the National Brick Manufacturers Association. Many boxes in use have too steep a slope with the consequent tendency for the sand to sink to the bottom in the lowest corners. When this occurs, the contents of the box should be dumped out to one side and never onto the pavement. It does not have enough cement to make a grout of the proper consistency, but even worse than this is the fact that after it is thrown out on the pavement it will fill the joints at the top and will not allow the grout to get down to the bottom of the brick. In making the first application, the joints should be completely filled but after settling, the grout will probably lack from ½ to ¾ an in. of reaching the top of the brick. As the second application of the grout is of a thicker consistency than the first, it is essential that the joints all be filled at the first application in order to insure that the second application will flow into and fill the remaining spaces.

The first application of grout is broomed ahead and into the joints with a heavy rattan street broom. The second and all subsequent applications that may be needed are pushed ahead with the squeegee. Considerable mortar is generally left on top of the brick after the second application to fill any low joints which may develop, rather than being obliged to bring the boxes back again. This material is not allowed to take its initial set before being finally finished, but it is generally necessary to add a little water to it in order to stiffen it up a trifle.

Of the two functions of the squeegee in finishing a brick pavement, one of them is to leave the surface smooth and the other, which is equally important, is to work all the air bubbles out of the grout. In order to insure that all these bubbles are worked out of the grout, there should be at least one trip made over the pavement with the squeegee where no attempt is made to finish, just simply starting the men down the stretch of pavement, one following the other, pushing the squeegee back and forth, until the entire length of the pavement has been covered. At the final finishing of the pavement, the squeegee should be pulled rather than pushed so that the men will not track up the newly finished surface. It should be pulled at an angle of about 45 degrees with the joints in the brick in order that it will not dig out the grout from between the brick and leave same lower than the general surface of the pavement.

**Quantity of Grout Required per Unit Area.**—With a grout composed of 1 part cement and 1 part sand, it has been found that 1 barrel of cement, with an equal volume of sand, will make sufficient grout to cover the areas below under the two types of bed for the brick:

4-IN. BRICK ON ORDINARY SAND CUSHION.

32 sq. yd. if repressed brick is used.
24 sq. yd. if wire-cut lug brick is used.

4-IN. BRICK ON ¾-IN. MORTAR BED.

30 sq. yd. if repressed brick is used.
22 sq. yd. if wire-cut lug brick is used.

It will be noted that by using the mortar bed instead of the customary sand cushion, an equal volume of grout covers a smaller number of square yards, this being due to the fact that when the sand cushion is used, some of the sand finds its way up between the brick and prevents the entrance of the grout for the full depth of the brick.

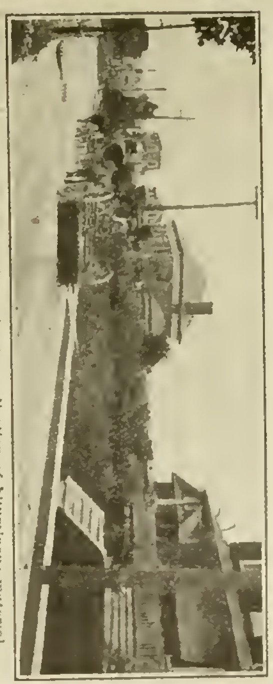
It has been found that 10 gals. of water are necessary to build complete a 4-in. brick pavement with a grout filler on a 4-in. concrete base.

**Labor Cost for Grouting Brick.**—In some of the state jobs the labor cost varies from about 1.6 cts. per square yard to 3.9 cts. These matters are so dependent upon the efficiency of the organization rather than upon the rate per hour, that the cost is largely dependent upon the foreman in charge. As a fair average figure for estimating purposes, Mr. Bilger states that when labor is 25 cts. per hour, the actual labor cost without making any allowance for overhead, etc., is about 2½ cts. per square yard of brick pavement.

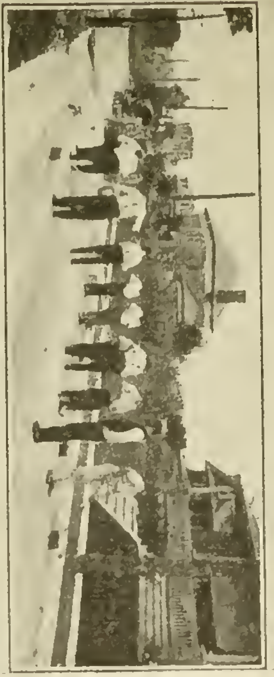
## DETAILED COST OF BITUMINOUS SURFACE TREATMENT WORK AT PHILADELPHIA.

During 1915, 149.1 miles of waterbound macadam roads were given surface treatment by the Bureau of Highways of Philadelphia, Pa., and 111 miles of roads were given dust layer treatment. The average cost of the bituminous treatment work has shown a steady decrease. In 1913 it was 7.3 ct. per square yard; in 1914, 5.8 ct. and in 1915, 5.03 ct. The reduced cost has been due both to the increased efficiency in the methods of performing the work and to the decreased amount of bituminous materials used.

When bituminous surface treatments were first started by the Bureau in 1912 there were only a few of the waterbound macadam roads in condition to warrant this treatment. The efforts of the Bureau, however, in repairing the roads, have been so successful that at the present time practically all the waterbound macadam highways have received bituminous surface treatment. The roads which are not in good repair are covered with a road oil which serves as a dust layer. This material is seldom used on the waterbound macadam roads, but it is still employed quite extensively on the dirt roads where it minimizes the dust nuisance. The roads, in general, are treated once a year with bituminous material and given a coat of gravel or chip. The method of operation is shown in the accompanying illustration. Table I, reprinted from the annual report of William H. Connell, Chief of the Bureau, shows the detailed cost of the



Machine broom sweeping prior to application of bituminous material.



Hand brooming, following machine broom work.

Applying the bituminous material with a pressure distributor.

Applying stone chips, following the application of the bituminous material

Sequence of Operations in Bituminous Surface Treatment Work at Philadelphia.

TABLE I.—DETAIL COSTS OF BITUMINOUS SURFACE TREATMENT WORK FOR YEAR 1915.

| Character of treatment material used. | Treatment number. | Square yards treated during 1915. | Aver. materials per sq. yd. — Gal. bituminous material. | Aver. materials per sq. yd. — Pounds covering material. | Average labor costs per sq. yd. — Sweeping — Hand. | Average labor costs per sq. yd. — Sweeping — Machine. | Average labor costs per sq. yd. — Covering. | Average labor costs per sq. yd. — Cleaning up. | Average labor costs per sq. yd. — Total. | Average material costs per sq. yd. — Bituminous material. | Average material costs per sq. yd. — Covering material. | Average material costs per sq. yd. — Total. | Average total cost per square yard. | Average total cost per sq. yd. First and retreatments. 1915. | Average total cost per sq. yd. First and retreatments. 1914. | Average total cost per sq. yd. First and retreatments. 1913. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refined coal tar—hot application Tarvia A........ | 1 | 165,904 | .29 | 17.3 | $0.0031 | $0.0006 | $0.0046 | $0.0006 | $0.0089 | $0.0246 | $0.0180 | $0.0426 | $0.0515 | $0.0491 | $0.0641 | $0.0824 |
| Refined coal tar—hot application Tarvia A........ | 2 etc. | 41,907 | .20 | 15.5 | .0027 | .0003 | .0048 | .0008 | .0086 | .0169 | .0156 | .0235 | .0411 | | | |
| Refined coal tar—cold application Tarvia B....... | 1 | 375,163 | .42 | 17.8 | .0046 | .0007 | .0058 | .0010 | .0121 | .0289 | .0186 | .0475 | .0596 | .0506 | .0566 | .0658 |
| Refined coal tar—cold application Tarvia B....... | 2 | 268,118 | .30 | 16.5 | .0037 | .0005 | .0052 | .0010 | .0104 | .0210 | .0162 | .0372 | .0476 | | | |
| Refined coal tar—cold application Tarvia B....... | 3, etc. | 360,702 | .26 | 15.5 | .0034 | .0004 | .0052 | .0011 | .0101 | .0180 | .0153 | .0333 | .0434 | | | |
| Refined water gas tar—hot application—Ugite.... | 1 | 29,299 | .29 | 17.3 | .0031 | .0006 | .0046 | .0006 | .0089 | .0232 | .0180 | .0412 | .0501 | .0501 | ..... | .0943 |
| Refined water gas tar—cold application—Ugite.. | 1 | 24,551 | .42 | 17.8 | .0016 | .0007 | .0058 | .0010 | .0121 | .0250 | .0186 | .0136 | .0557 | 0.456 | .0509 | .0698 |
| Refined water gas tar—cold application—Ugite.. | 3, etc. | 19,971 | .23 | 14.5 | .0003 | .0003 | .0055 | ..... | .0061 | .0138 | .0134 | .0272 | .0333 | | | |
| Asphalt cutback .................................. | 1 | 170,746 | 34 | 17.7 | .0045 | .0008 | .0056 | .0007 | .0116 | .0264 | .0178 | .0412 | .0558 | .0515 | .0738 | .0868 |
| Asphalt cutback .................................. | 2 | 43,781 | .28 | 15.9 | .0026 | .0005 | .0047 | .0007 | .0085 | .0222 | .0160 | .0382 | .0467 | | | |
| Asphalt cutback .................................. | 3, etc. | 54,832 | .23 | 15.0 | .0029 | .0007 | .0036 | .0009 | .0081 | .0191 | .0146 | .0337 | .0418 | | | |
| Asphalt—100 penetration—325°..................... | 3 | 2,610 | .25 | 15.2 | .0036 | .0008 | .0058 | ..... | .0102 | .0190 | .0169 | .0359 | .0461 | .0461 | ..... | ..... |
| Trinidad liquid asphalt "A"........................ | 1 | 2,035 | .44 | 17.7 | .0103 | ..... | .0145 | ..... | .0248 | 0394 | .0198 | .0592 | .0840 | .0840 | ..... | ..... |
| Special ugite .................................... | 3 | 32,400 | .21 | 14.0 | .0018 | .0005 | .0086 | .0014 | .0123 | .0166 | 0.150 | .0316 | .0439 | .0439 | .0577 | ..... |
| Totals (tars and asphalts)..................... | ........ | 1,592,055 | .32 | 16.7 | $0.0037 | $0.0006 | $0.0053 | $0.0009 | $0.0105 | $0.0229 | $0.0169 | $0.0398 | $0.0503 | $0.0503 | $0.0584 | $0.0730 |
| Asphalt road oil—dust layer—21°-23° Beaume.... | ........ | 1,173,585 | .23 | .... | ..... | ..... | ....... | ....... | ....... | $0.0111 | ....... | $0.0111 | $0.0111 | $0.0111 | $0.0141 | ....... |
| Grand total (sq. yd.)........................... | ........ | 2,765,640 | ... | .... | ..... | ..... | ....... | ....... | ....... | ....... | ....... | ....... | ....... | ....... | ....... | ....... |

bituminous surface treatment work for 1915. The average labor cost per square yard for the hand and machine sweeping, covering and cleaning up during 1915 was $0.0105, as compared with $0.0203 in the previous year.

The unit costs of labor and material during 1915, 1914 and 1913 were as follows:

| Labor and material. | Unit costs 1915 | 1914. | 1913. |
|---|---|---|---|
| Torpedo gravel, per 2,000 lbs., delivered on road.. | $2.03 | $2.14 | $2.50 |
| Trap rock chips, per 2,000 lbs., delivered on road. | 1.94 | 2.30 | 2.30 |
| Tarvia A, per gallon applied.................... | .085 | .085 | .085 |
| Tarvia B, per gallon applied.................... | .0692 | .07 | .07 |
| Ugite hot, per gallon applied.................... | .08 | .09 | .09 |
| Ugite cold, per gallon applied.................... | .06 | .08 | .08 |
| Asphalt cutback, per gallon applied............ | .0791 | .11⅔ | .12 |
| Asphalt road oil, per gallon applied............ | .0184 | .0523 | .... |
| Laborers, per 8-hour day.................... | 2.00 | 2.00 | 2.00 |
| Foremen, per 8-hour day.................... | 4.00 | 4.00 | 4.00 |
| Assistant foreman, per 8-hour day.............. | 3.00 | 3.00 | 3.00 |
| Teams, per 8-hour day.................... | 4.48 | 4.75 | 5.20 |

## DETAILED COST OF GRAVEL ROAD MAINTENANCE.

The accompanying tabulation (Table I) reprinted from the recently issued report of the State Highway Commission of Maine for 1915 shows the distribution of cost of maintenance by the patrol system of gravel roads on state highways in 1915.

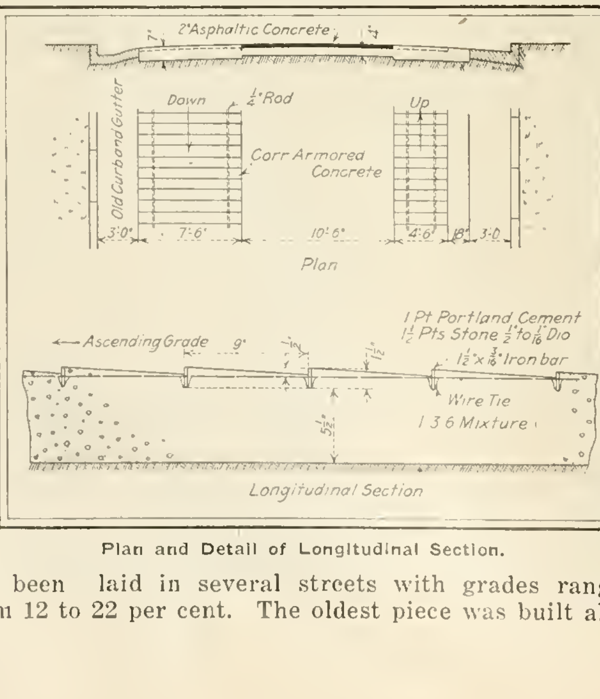
TABLE I.—DISTRIBUTION OF COST OF MAINTENANCE OF GRAVEL ROADS ON STATE HIGHWAYS, 1915.

| Town. | Miles. | Inspection. | Cutting bushes. | Raking rocks. | Dragging. | Road machine work. | Cleaning ditches and culverts. | End walls and culverts. | V-drain and stone base. | Guard rails. | Gravel surfacing. | Total cost. | Cost per mile. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fryeburg ................ | 8.71 | ...... | ...... | $ 82,88 | $ 192.56 | ....... | $ 83.30 | $ 0.64 | ....... | ...... | $ 276.49 | $ 635.87 | $ 73.00 |
| Woolwich ................ | 5.68 | $ 2.97 | $ 2.88 | 72.75 | 132.30 | $ 7.70 | 96.09 | ....... | ....... | ...... | 278.77 | 602.46 | 106.07 |
| Wiscasset ................ | 3.94 | ...... | 5.75 | 82.96 | 98.13 | ....... | 109.83 | ....... | ....... | ...... | 275.58 | 572.26 | 145.24 |
| Waldoboro ................ | 7.09 | 7.67 | ...... | 180.77 | 208.74 | ....... | 177.86 | ....... | ....... | ...... | 61.13 | 636.17 | 89.73 |
| Warren ................ | 5.86 | ...... | 8.55 | 111.55 | 82.84 | ....... | 82.97 | ....... | ....... | ...... | 79.31 | 368.18 | 62.83 |
| Northport ................ | 7.65 | ...... | ...... | 70.40 | 123.83 | ....... | 56.82 | 9.88 | ....... | ...... | 107.85 | 368.78 | 48.20 |
| Auburn ................ | 4.60 | ...... | ...... | 36.25 | 215.25 | ....... | 102.75 | 1.00 | $372.18 | $21.75 | 318.12 | 1,067.30 | 232.02 |
| Greene ................ | 2.28 | ...... | 1.00 | 78.26 | 61.74 | 24.33 | 10.44 | 136.06 | ....... | ...... | 80.92 | 392.75 | 128.39 |
| Leeds ................ | 1.45 | ...... | ...... | 65.98 | 37.52 | 44.75 | 22.56 | 73.00 | ....... | ...... | 122.65 | 366.46 | 252.73 |
| Monmouth ................ | 4.88 | ...... | 4.34 | 72.89 | 50.51 | ....... | 46.67 | ....... | ....... | ...... | 28.07 | 202.48 | 41.48 |
| Winthrop ................ | 2.80 | ...... | .33 | 28.74 | 20.33 | 4.17 | 19.23 | 2.00 | ....... | ...... | 72.08 | 146.88 | 52.45 |
| Farmington ................ | 3.62 | ...... | ...... | 52.13 | 59.29 | ....... | 227.03 | 2.88 | ....... | ...... | 281.00 | 622.33 | 172.19 |
| Strong ................ | 3.91 | ...... | ...... | 20.85 | 45.17 | ....... | 14.43 | ....... | ....... | ...... | 11.85 | 92.30 | 23.60 |
| Newport ................ | 4.30 | ...... | ...... | 44.97 | 135.72 | 23.00 | 27.28 | ....... | ....... | ...... | 148.50 | 379.47 | 88.25 |
| Carmel ................ | 6.96 | ...... | 1.75 | 158.64 | 66.38 | 30.00 | 20.16 | 5.92 | ....... | ...... | 339.41 | 622.26 | 89.40 |
| Dover ................ | 6.72 | 6.60 | 5.46 | 46.66 | 57.05 | 2.88 | 41.75 | ....... | ....... | ...... | 25.01 | 185.45 | 27.60 |
| Houlton ................ | 2.72 | ...... | ...... | 22.24 | 8.52 | ....... | 10.88 | ....... | ....... | ...... | 23.41 | 65.05 | 23.91 |
| New Limerick ................ | 6.69 | ...... | ...... | 64.22 | 63.84 | ....... | 19.35 | ....... | ....... | ...... | 39.62 | 187.03 | 27.94 |
| Trenton ................ | 6.02 | ...... | 7.54 | 109.27 | 146.42 | ....... | 43.00 | ....... | ....... | ...... | 126.47 | 432.70 | 71.87 |
| Whiting ................ | 9.23 | ...... | ...... | 73.74 | 110.31 | 40.75 | 34.84 | 135.68 | ....... | 36.67 | 681.89 | 1,113.88 | 120.68 |
| Oxford ................ | 3.77 | ...... | ...... | 1.44 | 21.34 | ....... | 10.98 | ....... | ....... | ...... | *75.67 | 109.43 | 29.02 |
| Totals ................ | 108.88 | $17.24 | $37.61 | $1,480.57 | $1,937.79 | $177.58 | $1,258.24 | $367.06 | $372.18 | $58.42 | $3,462.80 | $9,169.49 | †$ 84.21 |
| Percentages ................ | ...... | .188 | .41 | 16.1 | 21.1 | 1.93 | 13.7 | 4.00 | 4.05 | .63 | 37.7 | ......... | ....... |
| Cost per mile................ | ...... | .158 | .345 | 13.60 | 17.79 | 1.63 | 11.55 | 3.37 | 3.41 | .536 | 31.80 | ......... | ....... |

*Sand-clay. †Average.

## CONCRETE PAVEMENT ON 22 PER CENT GRADE.

A special type of concrete pavement is used by the city of Birmingham, Ala., for hillside work. This type has been laid in several streets with grades ranging from 12 to 22 per cent. The oldest piece was built about 3 years ago and has proved successful both as regards to wear and the assuring of a foothold for horses.



Plan and Detail of Longitudinal Section.

The pavement, as will be noted from the plan and section shown herewith, has a 30-ft. roadway. The center 10½ ft. is surfaced with asphaltic concrete for the convenience of automobiles. On each side the roadway is paved with corrugated armored concrete. J. D. Welt is Assistant City Engineer of Birmingham.

## STREET CLEANING WITH VACUUM CLEANERS AT ST. LOUIS, MO.

During the past summer the Street Division of the Department of Streets and Sewers of St. Louis, Mo., conducted a 60-day experimental test of a vacuum street cleaning outfit. This plant was owned by the Way-Cleanse Co. of Sandusky, O., and consisted of a machine for cleaning in gutters and a patrol machine for cleaning the remainder of the street. The following conclusions based on this experimental run are taken from the report of C. M. Talbert, Director Department of Street and Sewers submitted to the Board of Estimate and Apportionment:

Among the things which can be said in favor of the work of the machine, are:

First—A very complete removal from the street surface of all foreign matter and particularly what is known among those who study street refuse as "dust," this being the very fine and at times impalpable particles which lie close to the surface of the pavement and which has been found by bacteriologists to be the germ-carrying part of street refuse.

Second—By cleaning these streets every night, the department has been enabled to entirely eliminate street sprinkling as a practice. There has not been on the streets of the downtown section any street sprinkling since about the first day of July. These street sprinklers make from six to eight trips each business day over each of the downtown streets and from the very nature of their work, that is, their very slow movement and the fact that they must take the center of the street in order to properly cover the surface, complicate the traffic problem.

Third—This absence of the street sprinkler leaves a dry, clean, surface for traffic, and in these days when probably 75 per cent of the traffic is automobile, it adds greatly to the safety by eliminating the tendency to skid; the report of the police and others interested in traffic shows that there has been a great dimunition of accidents from such causes during the past thirty days. There must also be considered the general inconvenience to pedestrians from water from the sprinkler sprays.

Fourth—As would naturally be expected, the use of the vacuum system has materially reduced the labor necessary to keep clean the sewer inlets and catch basins. The superintendent of sewers reports a reduction in material removed of about 35 per cent. This proportion will be increased still further as the system becomes established and it is anticipated that the expense of cleaning sewer inlets will be reduced about 50 per cent. It has also very materially reduced the number of complaints of stopped or blocked sewers.

Fifth—From an examination of material taken from the streets, it does not appear that the asphalt surfaces are sensibly worn by the brooms.

Sixth—The more complete removal of dust and dirt from the streets, reduces, of course, the work of the white wings and while they have not been reduced in number during the experimental period, it is certain that if a permanent arrangement is entered into, some reduction will be made in their number. It will always be necessary, of course, any system of street cleaning to have white wings in the congested district during the business hours.

Among the disadvantages, is the inability to use the machine under any other conditions than when the roadway and gutter is perfectly dry. During our experimental run of 60 days there have been six nights on which work could not be successfully done. It would appear to me likely that during the rainy season, that is from the middle of March to the first of June, it would be necessary to use some form of street flushing at least twice per week. This is largely a matter of guess, as no two seasons are at all alike. There have been periods wherein the vacuum cleaner could undoubtedly be used a good portion of the time even in the month of March, which is one of our most troublesome months on account of the prevalent high winds. It must be borne in mind, of course, that the same rain that would stop the work of the vacuum cleaner would have a tendency to wash the dust into the sewer or if not heavy enough for that, to eliminate it through a natural sprinkling.

An examination into materials collected by the gutter machine and the patrol machine and the details of the materials collected by each showed that approximately 60 per cent of all street dust is found within 8 ft. of the gutter and that by far the greater part of the coarse dirt is collected from the gutter. A comparison of the districts shows the following: 1. Thoroughfares traveled practically exclusively by automobile. 2. Mixed automobile and horsedrawn vehicles, steel tired. 8. Those used almost exclusively by horsedrawn and steel tired vehicles.

It was found in the first type street dust passing a 200-mesh sieve 5.8 per cent and that retained 94.2 per cent. On the second type passing a 200-mesh sieve 10.9 per cent and that retained 89.1 per cent. On the third type passing a 200-mesh sieve 30.6 per cent and that retained 69.4 per cent; total, 100 per cent.

It would appear from this that the very fine dust is collected on streets that are subjected to steel tire traffic and the steel shoes of horses and that the automobile traffic tends rather to leave the dust in coarser particles.

The bacteriological examination shows that the gutter dust contained 270,000,000 germs per cubic centimeter and that the dust from the center of the street contained 249,000,000 germs per cubic centimeter.

## CONVICT LABOR ON HIGHWAY CONSTRUCTION IN ARIZONA.

The employment of convict labor in state highway construction in Arizona has effected a considerable saving to the state, according to the recently issued report of Lamar Cobb, State Engineer. The matter that follows has been taken from Mr. Cobb's report. The first work of this kind was done in 1913 on the highway from the Grand Canal to the Tempe Bridge in Maricopa County. In general two prison camps have been in operation: an honor camp of 35 to 50 men and a guarded camp of 75 to 100 men. Table I gives a comparative statement of prison labor maintenance in road construction from 1913 to 1916.

The prison labor work of the Arizona Highway Department has been in charge of Division Engineer F. G. Twitchell. In a paper presented last year before the Association of Arizona Highway Engineers Mr. Twitchell outlined the methods employed and the results obtained with this class of labor. Extracts from this paper follow:

The figures that follow are taken from the records of the camp known as Prison Road Camp No. 1. This camp was organized in December, 1913, on a small basis, with the intention of using it for general repair work and minor improvements. When first put in the field, it was made up of 29 men and 8 teams, under the direction of one foreman. Since that time it has expanded until now it has a force of 55 men and 24 teams, under the direction of three foremen and is capable of handling, and has handled, any class of road work.

Acting upon the principle that if a prisoner is worthy of being trusted he is worthy of being trusted to the fullest extent, the ordinary prison rules have not been enforced in this camp. The endeavor has been to avoid as far as possible anything that would keep the man constantly conscious that he was a prisoner. Responsibility for his actions has been placed upon himself.

Carrying out this idea, the men are dressed in civilian clothes, and with two exceptions are not restricted any more than in a free labor camp. The first of these two exceptions is that there is a set hour for going to bed, and the second is that the men are not allowed to leave the camp without permission, and then only to the extent of one mile free range. Under no circumstances are they allowed to go to town. One guard, who acts as night watchman for the camp, is employed, whose principal duty, outside of this, is to look after the clothing and equipment of the men.

The food furnished is on a par with that furnished in the best free labor camps, and better than that furnished in many. The average idea is that any kind of food is good enough for a prisoner, but that idea is based upon altogether wrong premises. It is not a prisoner that is being fed, but a workman, and this is a fact that must never be lost sight of. It is probably not necessary for me to remind you that a man poorly fed is a man who is discontented both in mind and body, whose work will reflect his state of being.

For sleeping quarters tents are furnished, which are heated in the winter time. Each man is furnished with a cot, mattress, sheets and blankets. One man is detailed as a laundryman, who takes care of all the clothing. An effort to have each man wash his own clothes did not prove successful.

The camp under discussion, during the period from Dec. 15, 1913, to Jan. 25, 1915, spent nearly $30,000 on the Globe-Roosevelt highway, and of this amount $10,477, or about one-third, was the cost of maintaining the pris-

TABLE I.—COMPARATIVE STATEMENT OF PRISON LABOR MAINTENANCE ON ROAD CONSTRUCTION, 1913 TO 1916.

| | Under Guard | | |
|---|---|---|---|
| | 1913-14, Bisbee-Tombstone, Sec. 1 | 1915-16, Bisbee-Tombstone, Sec. 2. | 1916, Phoenix-Yuma Arl. Agua Caliente. |
| Duration of work | 11 months. | 7 months. | 4 months. |
| Average number of men | 90 | 79 | 70 |
| Per cent on camp work | 10% | 14% | 17% |
| Cost per man per day— | | | |
| Groceries | .277 | .258 | .2076 |
| Meat | .175 | .1257 | .1313 |
| Fuel | .015 | .0196 | ..... |
| Total cost per man per day, feeding | .467 | .4033 | .3389 |
| Total cost per man per day— | | | |
| Tobacco | In groceries | .0163 | .0207 |
| Clothing | .121 | .0756 | .1315 |
| Medical | .013 | .0171 | .0040 |
| Lights | In groceries | .0175 | .0102 |
| Transportation | .131 | .0512 | .1721 |
| Haul supplies, teams | .019 | .0101 | .0203 |
| Haul supplies, truck | .... | .0213 | .0238 |
| Escapes | .017 | ..... | ..... |
| Guards | .385 | .4085 | .4068 |
| Equipment | .02 | .0507 | .0253 |
| Miscellaneous | .... | .0007 | .0028 |
| Cost per man per day, total | 1.173 | 1.0725 | 1.1566 |
| Cost per man working day, total | 1.816 | 1.6063 | 1.6977 |
| | Honor | | |
| | 1913-15, Globe-Roosevelt Highway. | 1915-16, Tucson-Flor. Highway, Sec. 2. | 1916, Phoenix-Yuma Hy., Wellton-Mohawk Division. |
| Duration of work | 31 months | 12 months | 2½ months |
| Average number of men | 31 | 39 | 29.5 |
| Per cent on camp work | 19% | 18% | 21% |
| Cost per man per day— | | | |
| Groceries | .348 | .3048 | .5288 |
| Meat | .205 | .1546 | .0976 |
| Fuel | .... | .0317 | ..... |
| Total cost per man per day, feeding | +.553 | +.4911 | +.6264 |
| Cost per man per day— | | | |
| Tobacco | .023 | .0203 | .0199 |
| Clothing | .139 | .1636 | .1189 |
| Medical | .014 | .0189 | .0093 |
| Lights | .006 | .006 | .0048 |
| Transportation | .... | .0345 | .2223 |
| Haul supplies, teams | .... | .0199 | .0481 |
| Haul supplies, truck | .... | .0721 | .... |
| Escapes | .... | .0439 | .0438 |
| Guards | .052 | .1133 | .1731 |
| Equipment | .... | .0926 | ..... |
| Miscellaneous | .... | .1178 | .1449 |
| Cost per man per day, total | .787 | 1.188 | 1.421 |
| Cost per man working day, total | 1.29 | 1.517 | 1.9087 |

+Men in honor camps are better fed.
Phoenix-Yuma, Arlington-Agua Caliente, 35 mile haul for supplies.
Phoenix-Yuma, Wellton-Mohawk, 7 mile haul for supplies.
Tucson-Florence Highway, Section 2, 5 to 20 mile haul for supplies.

oners. Of the balance, the maintenance of teams took nearly $6,000, paid labor took $3,000, the material bill for culverts, cement, powder and similar items was over $6,000, and maintenance and depreciation of the equipment was about $3,000.

On the Globe-Roosevelt highway in 1914 it cost us 78 7/10 ct. per day to keep a man, this covering food, clothing, medicine, tobacco and the night watchman. The cost per day was for every prisoner in the camp, including the camp force of cooks, flunkeys, etc., who are generally known as "non-producers," and for every day in the year, including Sundays and bad weather days, when no work was going on. The cost per man per working day, by which is meant the cost of putting the prisoner on the job, for every day he actually worked, was $1.29. This working day cost includes the cost of the camp force on Sundays, or days when the weather would not permit of work, and on days when the camp was moving. During the period 13 months referred to the total number of days lost from these causes was 97, or 25 per cent of the total time the camp was in operation on this job. It also had to include the cost of transporting the men from the prison to the camp, which amounted to a total of $1,252, or 15 4/10 ct. per man per working day.

The work was largely repair work and construction, was scattered over some 10 miles of road, and the average water haul was 3 miles and the average supply haul was 21 miles. The unit costs of the work done were:

Clearing and grubbing—largely mesquite and chaparal—the average cost of some 57 acres was $9.13 per acre.

Solid rock excavation—total quantity moved, 4,392 cu. yd. Where this work was so located that full benefit could be derived from the necessary drilling and shooting, the cost ran from 65 ct. to 85 ct. per yard. When it consisted largely of shooting off projected points, and widening the road at narrow places, the cost was from $1.25 to $2.50 per yard. The average cost for the total quantity moved was $1.274 per yard.

Loose rock and boulders—total quantity 9,000 cu. yd., ranging in cost from 26 ct. to 81 ct. per yard—this latter being material that had to be shot, although it could not properly be classified as solid rock—average cost 66 3/10 ct. per yard.

Earth borrow and excavation—total quantity 20,428 cu. yd., ranging in cost from 14 ct. to 45 ct. per yard. Most of this work was on steep hillsides. Average cost 25 2/10 ct. per yard.

Foundation excavation—total quantity 688 cu. yd.; average cost 56 1/10 ct. per yard.

Dry walls—total quantity 126 cu. yd.; cost $1.185 per yard.

Rubble masonry—total quantity 612 cu. yd.; average cost $3.82 per yard.

Concrete—total quantity 116 cu. yd., average cost $13.16 per yard. This high cost is principally due to the small quantity placed, which did not permit the men to obtain experience and skill in form building and concrete mixing.

Ditching—total quantity 5,209 cu. yd., average cost 35 3/10 ct. per yard.

The following costs relate to the work done by this same camp on the Tucson-Florence highway in Pima County. This work is new construction, and in consequence of not being scattered, is being done cheaper. The average water haul has been 3 miles and the supply haul 9 miles, and it has been possible to reduce the cost of a prisoner working day to $1.144.

The unit costs on the work have been as follows:

Clearing and grubbing, $15.82 per acre.
Earth excavation and borrow, $0.182 per cu. yd.
Solid rock excavation, $0.844 per cu. yd.
Ditching, $0.175 per cu. yd.
Concrete, $9.88 per cu. yd.

## METHOD AND COST OF STREET FLUSHING AT WORCESTER, MASS., BY TROLLEY FLUSHERS.

The city of Worcester, Mass., is stated to be the first municipality in the United States to adopt the trolley car method of street flushing. Cleveland, O., to be sure, developed a flusher for its own use, but this did not embody many of the features of the new car used at Worcester, particularly the swinging arm, which enables the machine to cover an extremely wide street, the flushing at all times going in the proper direction during the swinging of the arm outward or inward. The car used at Worcester is manufactured by the American Car Sprinkler Co. It was constructed to cover the demand of the city, and the first one was placed in operation there is 1915. At the second annual convention of the Society for Street Cleaning and Refuse Disposal last October, Mr. A. T. Rhodes, Street Commissioner of Worcester, presented a paper giving the following data on the work of this machine.

The machine operated through the entire season with great satisfaction, together with several of the old style car sprinklers. In fact, the operation was so satisfactory that in the year 1916 the old style street sprinkling was abandoned entirely, and the new style of flushing has been operated on all types of permanent paving, including grouted, granite block paving—of which the city has the first piece in existence in the United States—sand joint block paving; asphalt and Topeka, both with and without a concrete base; Hassam paving, both with and without a bituminous top; wood block paving; brick paving; and a small section of bitulithic. There have been during the two years no noticeable defects occurring in any of these types of paving, through the operation of the flusher. The sand joint granite block paving, which it would be expected would feel the effects to the greatest extent, has been kept in a very clean and sanitary condition, as it has been possible to wash out the joints thoroughly between the blocks and clean the street in a manner much more satisfactory than the old machine broom style, or any other style in use previous to the adoption of this flushing system.

The machine used is a trolley car, containing a tank with a capacity of 2,900 gal., which is filled from hydrants constructed between the rails or tracks of the trolley system, covered by the ordinary sewer manhole cover, with an attachment on it for easy removal, whenever it is necessary to remove it. This is connected with the car by a flexible leather pipe for filling the tank in the car. The pressure for flushing is obtained by a centrifugal pump having a maximum capacity of from 500 to 600 gal. per minute, operated at a speed of 2,600 revolutions per minute and working under a normal working pressure of 80 lb. The pumps are equipped with a by-pass enabling the operator to cut the pressure down to as low as 30 lb., giving a very good range to work from if a lower pressure is desired. The pump is operated by a 45 hp. General Electric motor. The operation of the entire machine is handled by three men.

On the wide streets there are five nozzles working in the direction the car is going, three on the car and two on the swinging arms. One of the three nozzles on the car on a double track street catches the refuse lying upon the core of paving between the two tracks and throws it onto the opposite bound track, the return trip in the opposite direction catching that material and carrying it to the gutters.

Too much cannot be said in regard to sprinkling the pavement within an hour ahead of the time of flushing. This softens up any deposits, which are stuck down to the pavement, soaking them up and making them easy to remove when the flusher operates.

All cars, also the auxiliary trucks, which operate over streets having no car tracks, are equipped with Servis Recorders, by the records of which the Street Department can see whether or not the car has been busy through the entire night.

At present the city is operating two trolley flushers. Worcester covers each night 5.09 miles by tractor, and 21.3 miles by car flushers. With the preliminary sprinkling such as is done in Worcester a car flusher will cover about 10.5 miles of streets per night, each, varying from 25 ft. to 75 ft. in width between curbs. An average eight hours' work for a car doing both its own sprinkling and flushing is about 9 miles. During the 8 hours' work a car flusher will distribute approximately 95,700 gal. of water. The truck flushers, of which the city has two, in sprinkling and flushing cover each night a trifle over 5 miles between them, and some additional flushing ahead of the trolley flushers on account of trolleys having too much and trucks too little area to cover. A truck flusher will distribute approximately 43,750 gal. of water. Water for sprinkling and flushing is furnished gratis by the city. One car load of water sprinkling a street 37 to 45 ft. between curbs will do 1 mile of roadway. One carload of water flushing a street 37 to 45 ft. in width between curbs will do ¼ to ⅓ mile of roadway. The sprinkling and flushing is done under contract with the American Car Sprinkler Co. at the following rates:

| | Sprinkling, per mile. | Flushing, per mile. |
|---|---|---|
| Streets 25 ft. wide | $ 396.00 | $ 448.80 |
| Streets 30 ft. wide | 464.64 | 522.72 |
| Streets 35 ft. wide | 533.28 | 596.64 |
| Streets 40 ft. wide | 564.96 | 633.60 |
| Streets 45 ft. wide | 596.64 | 670.56 |
| Streets 50 ft. wide | 665.28 | 749.76 |
| Streets 55 ft. wide | 733.92 | 823.68 |
| Streets 60 ft. wide | 929.28 | 1,045.44 |
| Streets 65 ft. wide | 997.92 | 1,119.36 |
| Streets 70 ft. wide | 1,129.92 | 1,272.48 |
| Streets 75 ft. wide | 1,198.56 | 1,346.40 |
| Streets 80 ft. wide | 1,261.92 | 1,420.32 |

The American Car Sprinkler Co. pays the Street Railway Co. for power and operates the cars with its own help. The assessments are made against the abuttors on the streets flushed and sprinkled, so much a running foot, according to the width of the street, as follows:

| | Lin ft. |
|---|---|
| Streets 25 ft. wide | $0.03½ |
| Streets 30 ft. wide | .04 |
| Streets 35 ft. wide | .04½ |
| Streets 40 ft. wide | .04¾ |
| Streets 45 ft. wide | .05 |
| Streets 50 ft. wide | .05½ |
| Streets 55 ft. wide | .06 |
| Streets 60 ft. wide | .07½ |
| Streets 65 ft. wide | .08 |
| Streets 70 ft. wide | .09 |
| Streets 75 ft. wide | .09½ |
| Streets 80 ft. wide | .10 |
| Streets 100 ft. wide | .11⅝ |

The American Car Sprinkler Co. covers all streets under contract each night, except that under the 48-hour law on the down-town streets the work is split into two 4-hour shifts for Saturday night and Sunday night, giving a 48-hour total for the week's work.

Previous to the adoption by this city of flushing nights, the streets were sprinkled under the same system during the day. Under the sprinkling system during the day the water simply laid all the dust and other refuse which had accumulated upon the street surface right where it landed, forming a greasy, slippery scum on the surface, which was extremely dangerous to vehicular traffic, and through its slipperiness causing many accidents. It has been found that with the flushing at night the city has been able to discontinue the sprinkling during the day, thus obviating these very dangerous conditions and leaving a clean, dry street through working hours.

When the day sprinkling was in operation, three car sprinklers, making several trips over each street every day, covered the same area now covered by two flushers, making one trip nightly for sprinkling and flushing combined, the flushers working 8 hours and the sprinklers under the old method of 14 hours.

The amount of water used under the flushing system is about 60 per cent of that used under the old style day sprinkling, while the present combined sprinkling and flushing uses about 85 per cent of the amount.

The cost of catch basin cleaning has been just about doubled on streets which are flushed. The average cost per catch basin per year for cleaning was $1.95, and on streets flushed this has been increased to $3.90. However, there is no doubt but that it has been of great benefit to the street cleaning end, a great deal of the refuse and deposits being flushed through the catch basins and into the sewer and entirely gotten rid of.

Previous to the installation of this system of flushing the Street Department operated two machine broom squads, which worked at night, covering these paved streets from two to three times per week. This work was not very satisfactory, and it was also a difficult matter to keep track of labor during the night hours. This has been discontinued entirely, the only cleaning necessary being taken care of by the push cart men the first thing in the morning, who clean up the gutters as the first duty they perform on reaching their stations, and owing to the fact that their street is absolutely clean of any material when they reach it. Machine broom work amounted to about $14,000.00 yearly.

The following cities have adopted the flushing system, using the American car sprinkler car flushers:

Worcester, Malden, Mass.; Manchester, N. H.; New Bedford, Mass.; Springfield, Mass.; Somerville, Mass.; Syracuse, N. Y.

## CONVICT LABOR ON ROAD CONSTRUCTION IN MAINE.

The first attempt in Maine to use the labor of prisoners for the improvement of highways was made during the season of 1915 by the State Highway Commission. The results accomplished are described in the recently issued report of the Commission, from which the following notes are taken:

The Commission entered into an agreement with the county commissioners of Cumberland County on May 11th, for working prisoners upon road construction in the towns of Windham and Raymond.

The county furnished and transported prisoners to and from the road camp, provided necessary guards, purchased all food, and guaranteed that the average daily cost for raw material constituting the food for prisoners, guards, and all state superintendents should not exceed 50 ct. per day per man.

The state furnished all camp outfit, including buildings, beds, bedding, cooking utensils and food, including that for the guards and cook. The state furnished all tools and equipment and paid the wages of the superintendent, foremen and cook.

Work was started June 1 and finished Dec. 11. The work consisted of grading and surfacing with sand-clay 2 miles of road in Windham and 1 mile in Raymond. The force was composed of a superintendent at $4.50 per day, two foremen at $3.00 and board, one rollerman at $2.75 with board, one cook at $15.00 per week with board, one timekeeper at $40.00 per month. The average number of teams per day was 7.7, and the rate was 50 ct. per hour, or $4.50 for a 9-hour day. The county furnished 40 laborers, 3 of whom were used constantly as helpers to the cook. Three guards were paid by the county at the rate of $17.50 per week and board.

All bills for camp equipment and supplies were approved by the sheriff and also by the superintendent in charge, before being passed by the Commission.

The cost of the work is shown as follows:

| | |
|---|---|
| Raw materials | $ 3,815.86 |
| Camp and equipment | 833.84 |
| Tel. and express | 462.28 |
| Materials, superintendence and cook | 3,919.51 |
| Teams | 4,181.33 |
| Surveys and engineering | 801.19 |
| Total | $14,014.01 |

The prisoners were allowed Saturday afternoon and Sunday for recreation and rest.

The equipment consisted of one 10-ton steam roller, one watering cart, one pump, one disc-harrow, one plow, two road machines (borrowed) and an old farm house, in which the guards and cook lived. A dining-room was built in connection with this farm house of sufficient size, 10 ft. x 30 ft. x 6 ft., to seat forty men, and a camp was built to provide sleeping accommodations for the prisoners. This camp was 18 ft. x 40 ft. x 12 ft. high, with an addition of 18 ft. x 10 ft. x 6 ft. high.

The force worked a total of 46,351 hours or the equivalent of 5,150 1-9 9-hour days. The cost of raw material alone delivered at the camp averaged $ .83 per day for each day's labor performed. Taking the gross number of days' board furnished, superintendent, rollerman, guards, cook and prisoners, 7,985, the average cost of raw material delivered at the camp per day per man was $ .53577.

The above figures make no allowance for rental or depreciation of camp and equipment nor for the expense of preparing food.

Careful measurements of the work performed in grading and surfacing the three miles of road disclose the fact that 7,696 cu. yd. of grading, unclassified, cost $7,977.05, or an average cost of $1.036 per cu. yd., and 6,655 cu. yd. of sand-clay surface cost $4,117.49 or an average cost of $0.618 per cu. yd. The grading was not difficult except in one cut, when probably 1,500 yd. of boulders and loose rock was handled. The cost seems unreasonably high and reflects the inefficiency of the labor. On the other hand the surfacing was done at a very reasonable cost. The clay, 2,550 cu. yd., was hauled an average distance of 1 mile. The sand, 4,105 cu. yd., was hauled an average distance of ½ mile.

It is stated that if the highway commission's foremen could be deputized as guards it is thought better results would obtain.

## COST DATA ON STREET CLEANING IN PHILADELPHIA, PA.

During the past year special effort has been made by the Bureau of Highways and Street Cleaning, of Philadelphia, to obtain and classify as much data as possible as to the cost and most effective method of street cleaning. Not only have automobile flushers been made the subject of special investigations, but each kind of apparatus employed has been studied as carefully as possible and the results analyzed in the effort to ascertain the method of operation producing the best results. A synopsis of the actual costs of operation and detailed studies of the costs of cleaning the different classes of streets with the different forms of apparatus are shown in Table I, which is reprinted from the report of William H. Connell, Chief of the Bureau.

TABLE I.—STREET CLEANING COST DATA—UNIT COST PER 1,000 SQUARE YARDS.

| | —Machine broom— Unit cost—Spl. tests. | | | | | | Squeegee | | Flusher | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| District No. | Granite block | Brick | Wood block | Sheet asphalt | Average unit costs All classes | Average unit costs District reports | Aver. unit costs Special data | Aver. unit costs Dist. reports | Aver. unit costs Special data | Aver. unit costs Dist. reports | Aver. unit costs Dist. reports* |
| 1-A | .183 | .... | .... | .131 | .179 | .218 | .131 | .229 | .082 | .... | .152 |
| 1-B | .220 | .193 | .... | .128 | .212 | .176 | .174 | .165 | .108 | .... | .165 |
| 2 | .290 | .211 | .177 | .160 | .280 | .275 | .130 | .132 | .085 | .... | .191 |
| 3 | .266 | .171 | .135 | .145 | .252 | .310 | .118 | .175 | .143 | .277 | .290 |
| 4-A | .243 | .... | .203 | .188 | .241 | .210 | .176 | .282 | .250 | .... | .225 |
| 4-B | .242 | .218 | .205 | .168 | .216 | .377 | .115 | .223 | .127 | .... | .151 |
| 5 | .271 | .218 | .157 | .182 | .232 | .313 | .218 | .166 | .117 | .... | .120 |
| 6 | .234 | .178 | .... | .163 | .205 | .232 | .137 | .179 | .119 | .320 | .127 |
| Average | .246 | .193 | .166 | .159 | .226 | .277 | .148 | .179 | .106 | .... | .179 |
| *Blockmen. | | | | | | | | | | | |
| Gallons of water used per 1,000 sq. yd. cleaned | | | | | | 98 | .... | 240 | .... | 522 | .... |
| Cubic yards of dirt removed per 1,000 sq. yd. cleaned | | | | | | .118 | .... | .044 | See note | | .048 |

The data in this table are based on the following assumptions regarding the cost of labor and material:

| | |
|---|---|
| Blockmen | $ 1.50 |
| Gangmen | 1.75 |
| Machine broom | 5.50 |
| Squeegee | 6.00 |
| Dirt cart | 3.50 |
| Dirt wagon | 5.00 |
| Sprinkler | 5.00 |
| Automobile flusher | 15.00 |

The cost of water, 4 ct. per 1,000 gal., is included in the special test data, but not in the district daily report costs. District Nos. 3 and 6 operated automobile flushers, the flusher dirt being removed by blockmen. The squeegees were used only on sheet asphalt and wood block streets.

## DIAGRAMS FOR THERMAL CORRECTIONS FOR ROAD OIL AND FOR CONTENTS OF TANKS.

The specifications of the Road Department of Los Angeles County, California, for road oil for macadam contain the following clause for thermal corrections:

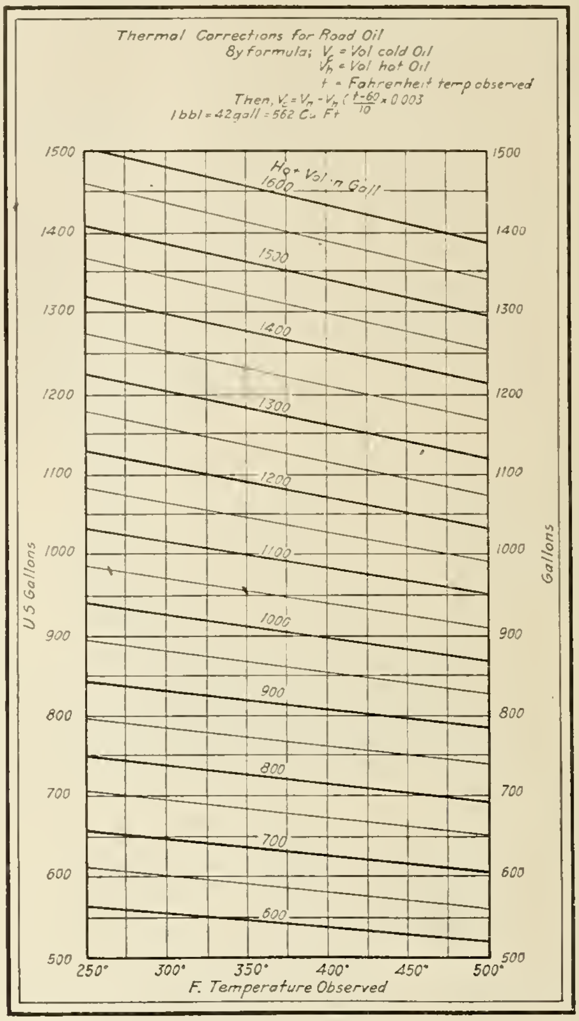


Diagram for Determining Thermal Corrections for Road Oil.

In determining the quantity of oil delivered, the correction for expansion by heat shall be as follows:

From the measured volume of oil received at any temperature above 60° F. an amount equivalent to 0.3 of 1 per cent for every 10° above said 60° F. shall be substracted as the correction for expansion by heat.

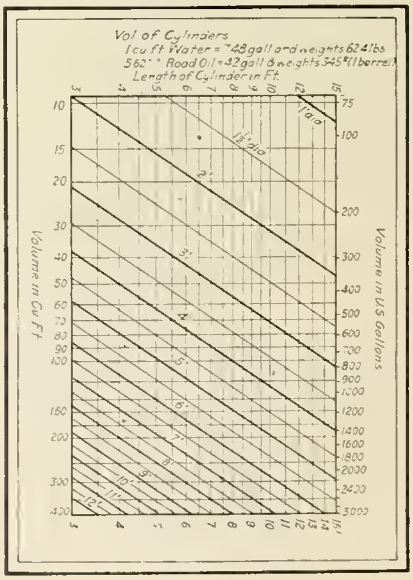


Diagram for Finding Contents of Tanks.

For the purpose of measuring this oil, a temperature of 60° F. shall be deemed normal temperature.

The accompanying diagram was devised by E. Earl Glass of the Road Department for applying the thermal correction. The following example illustrates the method: A tank received measures 1,100 gal. of oil at 375° F. The slant line 1,100 gal. hot oil intersects the 375° vertical line at 995 gal., which would be the 60° F. volume of the load. The chart is used by the inspectors on road oiling.

The other diagram, also devised by Mr. Glass, is used for finding the contents of all ordinary sized tanks used in road oiling.

## A METHOD OF GRADE CALCULATIONS FOR STREET INTERSECTIONS.

Studies with a view to arriving at better conditions of easy grade transitions and standard crown for street intersections have been completed recently by Mr. R. G. McMullen, Assistant Engineer, Department of Public Works of Portland, Ore. As a result of these studies Mr. McMullen has devised a method of constructing street intersections, the main feature of which is a transition of grade across intersections without the abrupt break usually found at the property lines. The method also provides for the calculation of grades to produce the results noted above, and for the giving of adequate data for record before work begins. By this method the grades may be decided by calculation to a known result, without depending upon the experience of the foreman. The results of Mr. McMullen's studies were submitted to the Department as a report, and from this the following matter has been abstracted.

The proposed method of grade calculation in the city of Portland is described in an ordinance prepared by Mr. McMullen, which is printed below in full:

### Proposed Method of Grade Calculation in the City of Portland.

The grades of the property lines and curb lines shall be calculated from the grades established by ordinance at the center intersection of streets.

The grades of the roadway shall conform to the parabolic crowns hereinafter described, and be controlled by the grades of the gutter lines and center intersection.

For the calculation of grades on all intersections where the established grades do not exceed 4 per cent. first calculate the grade at the property line, at the center of each street, which shall conform to a straight line between the centers of the adjacent cross streets, provided that the grade from the center intersection to the property line shall not exceed .02 per foot. From these points calculate the grade of the block corner, by taking the means of the relative grade points thus obtained plus three-tenths of 1 ft.

The crown center or high point of the roadway shall be calculated laterally off true center toward the upper side of the roadway, a distance of three times the difference in elevation of the corresponding curb grades.

The crown centers shall be connected by a curved line, described on their greater radius, and any point along the crown centers within the block lines shall be controlled by the one-quarter point grade hereinafter determined. From the crown centers the lateral grade to the gutter lines shall be parabolic.

At the intersection of the crown centers, the center shall be "sprung" or the elevation arbitrarily raised five-tenths of 1 ft. plus the lateral and longitudinal offsets, from true, to crown center, for a 36-ft. intersection and proportionally increased or decreased for other widths.

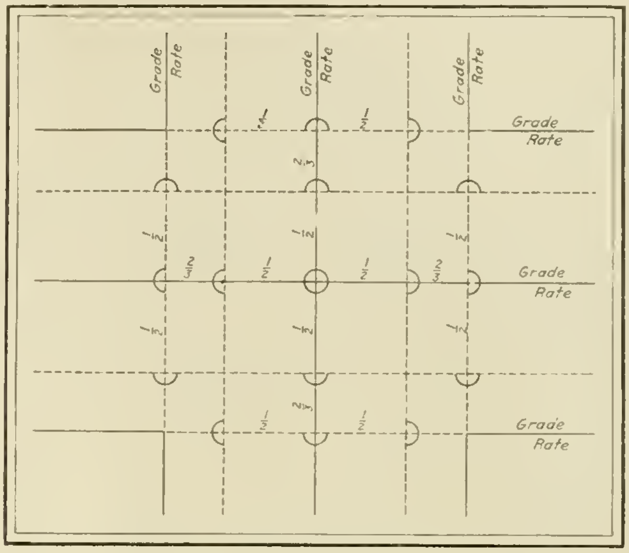


Fig. 1—Method for Obtaining Controlling Points.

Where roadways of different widths intersect use the proportion for superelevation of the widest roadway.

From the center intersection of the crown centers, to the crown center opposite the block corners the grade shall be a straight line, and from any point along this line the lateral grade shall be parabolic to the curving crown center line grade.

Within the crown center grade platform the grade shall radiate parabolically from the crown center lines to the sides of the center grade platform. The one-quarter control point of the center platform shall be obtained by taking one-third of the total fall from the crown center intersection to the gutter line on the center of the respective crown center curve and subtracting this from the crown center intersection.

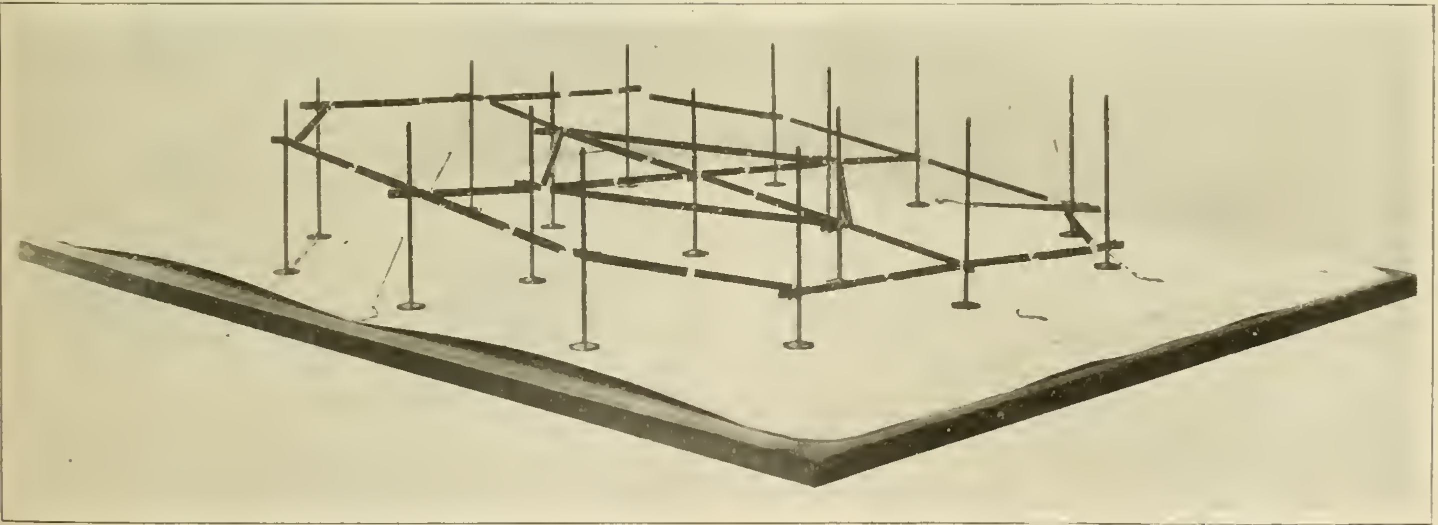


Fig. 2—Visualization of Controlling Points on 12 Per Cent and 6 Per Cent Grades.

The grade of the property line or side line of the street shall be a straight line between such points, unless a vertical curve or grade establishment intervene between such points, then such property line grade shall conform to the intervening grade.

The lateral grades of the sidewalk area between the curb line and property line shall be preferably 2 per cent descending to the curb, but optional with the City Engineer to increase lateral grade to 4 per cent, opposite block corners, provided the lateral rate of 2 per cent is again maintained at a point 12 ft., or in distance three times the rate of grade, back from the block centers.

For all hard surface pavements the proportion of crown shall increase or decrease in the ratio of five-tenths of 1 ft. crown to 36 ft. of roadway, and the elevation of the crown be fixed by the elevation of the high gutter line.

The establishment of a grade point on the curb at the center of the sidewalk corner shall be optional with the City Engineer.

For the calculation of grades on intersections where the established grades exceed 4 per cent first calculate the grade on the respective center lines to the point of intersection of the respective curb lines at the rate of one-half of such established gradient. From the above points of grade on the intersecting curb lines, calculate the grade to the respective property lines at the rate of two-thirds of such established gradient.

The lateral grade of the sidewalk shall conform to an equalized grade from points on the property line, in distance three times the rate of grade, back from the block corner, at which points the lateral grade shall conform to a two per cent descending grade to the curb as hereinbefore set forth.

From the grade points on the center lines of the respective streets opposite the property lines, calculate the grade of the curb, by taking the rate of grade, within the curb line platform or one-half the established gradient, laterally plus or minus for one-half the width of roadway, and calculate the curb grades, opposite the block corner. This gives the eight basic points for the complete intersection.

Proceed as hereinbefore set forth by establishing the gutter depths, thus fixing the gutter line, calculating the crowns from the high gutter ine, using the ratio, plus or minus, of five-tenths to 36 ft., determining the crown center by offsetting from true center three times the difference in elevation of opposite curbs, connecting by curved lines the crown centers on their greater radius, except on grades exceeding 8 per cent connect the crown centers of the high quarter by their least radius, where the confining grades are descending to the intersection.

The grades of the crown centers shall conform to the rates as before described, full rate as established outside of property lines, two-third rate from property line to curb line.

The points of intersection of the crown centers with the property line and curb line shall be fixed points of grade, from which further calculation necessary will be based. Nothing in this ordinance shall be construed as a change of grade.

The grade of the roadway shall be governed by the gutter lines and crowns and the type of the improvement of the roadway, provided that on intersections covered by an elevated plank roadway, bridge or viaduct, the grades of the intersections shall conform to such elevations recommended by the City Engineer.

Provided, further, that the method of calculating grades herein described, shall affect only such work as will in no way conflict with the permanent improvements made under former ordinances governing grade calculation.

Provided further that on streets having car tracks, the crown centers shall be so calculated that car tracks can be constructed on their respective franchise lines, in accordance with standard practice.

On summits, with descending grades in all directions, or basins with ascending grades in all directions, the intersection shall be made level.

A particularly interesting feature of the studies was the use of models for visualizing the grades. An example of how these were employed is given below. In Fig. 1 is shown the method by which the eight controlling points are obtained. The eight points are the curb grades opposite the block lines. The grade rate is the rate established from one certain intersection to the next. After establishment of the eight parts the remainder of the intersections are of no further use, as the final surface grades are controlled by the gutter lines, crowns, crown centers and platforms. Figure 2 shows a visualization of Fig. 1 on a 12 per cent and a 6 per cent crossing grades. The horizontal scale in this is ½ in. to 1 ft. and the vertical scale 1 in. to 1 ft. This does not show the property lines. Only the center and curb lines with the black paper strip connecting the different parts laterally and diagonally are shown.

These models are made on a plain drawing board, and set up over any convenient scale, from 1 ft. to 1 in. up to 10 ft. to 1 in.

The vertical scales are all alike and made of a brass post, graduated to inches and tenths of an inch, firmly attached to the base, which has three small points that are pressed into the board to hold the instrument vertical.

A sliding clamp encircles the post and has a notched hole through the end for holding the thread at the proper height.

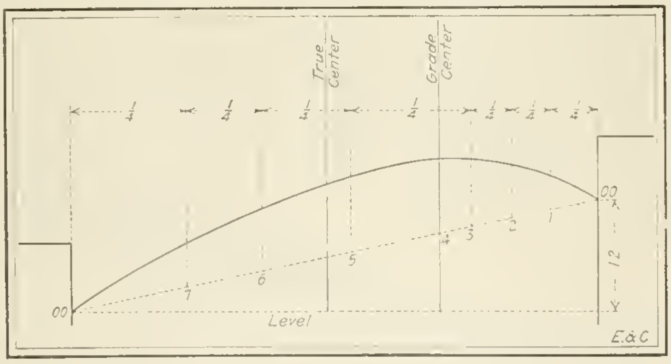
The readings on the post are exactly opposite the thread hole, and any one of the three points in the base are exactly under the thread hole.

The clamp moves up and down by releasing pressure on the wings of the spring, also turns horizontally in same plane around post to any point desired.

After threading the model, strips of black paper are hung over the threads to accentuate the lines in photography.

TABLE I.—ORDINATES FOR PARABOLIC ROADWAY CROWNS FOR 36-FOOT ROADWAY.

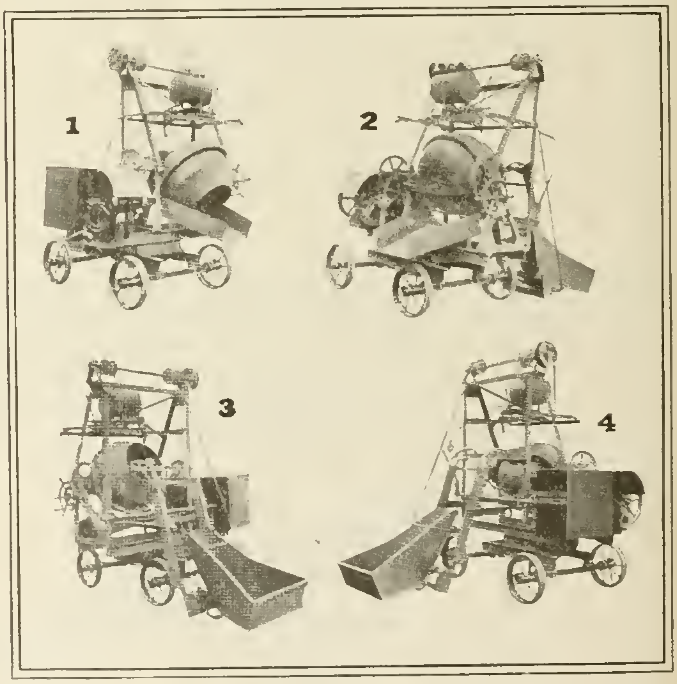
Center of roadway is three times the vertical distance between gutter lines off of true center to high side of street.



| Dif. in elev. of gutter lines. | Dist. betw. dist. ordinates off | | | | Ordinance | | | Cr. Centr. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper side | Lower side | True center | Cutter line | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Cutter line. |
| 0.0 | 4.5 | 4.5 | 0.0 | 00 | 0.21 | 0.37 | 0.47 | 0.50 | 0.47 | 0.37 | 0.21 | 00 |
| 0.2 | 4.35 | 4.65 | 0.6 | 00 | 0.23 | 0.42 | 0.51 | 0.60 | 0.58 | 0.47 | 0.29 | 00 |
| 0.4 | 4.20 | 4.80 | 1.2 | 00 | 0.25 | 0.46 | 0.61 | 0.69 | 0.68 | 0.57 | 0.34 | 00 |
| 0.6 | 4.05 | 4.95 | 1.8 | 00 | 0.28 | 0.50 | 0.67 | 0.77 | 0.81 | 0.68 | 0.41 | 00 |
| 0.8 | 3.90 | 5.10 | 2.4 | 00 | 0.30 | 0.54 | 0.72 | 0.85 | 0.88 | 0.75 | 0.46 | 00 |
| 1.0 | 3.75 | 5.25 | 3.0 | 00 | 0.31 | 0.58 | 0.78 | 0.91 | 0.97 | 0.83 | 0.52 | 00 |
| 1.2 | 3.60 | 5.40 | 3.6 | 00 | 0.33 | 0.61 | 0.83 | 0.98 | 1.06 | 0.91 | 0.57 | 00 |
| 1.4 | 3.45 | 5.55 | 4.2 | 00 | 0.34 | 0.64 | 0.87 | 1.04 | 1.13 | 0.99 | 0.62 | 00 |
| 1.6 | 3.30 | 5.70 | 4.8 | 00 | 0.36 | 0.66 | 0.91 | 1.08 | 1.21 | 1.06 | 0.67 | 00 |
| 1.8 | 3.15 | 5.85 | 5.4 | 00 | 0.37 | 0.68 | 0.94 | 1.13 | 1.28 | 1.14 | 0.72 | 00 |
| 2.0 | 3.00 | 6.00 | 6.0 | 00 | 0.37 | 0.70 | 0.97 | 1.17 | 1.35 | 1.20 | 0.77 | 00 |
| 2.2 | 2.85 | 6.15 | 6.6 | 00 | 0.38 | 0.72 | 0.99 | 1.20 | 1.41 | 1.27 | 0.82 | 00 |
| 2.4 | 2.70 | 6.30 | 7.2 | 00 | 0.38 | 0.73 | 1.01 | 1.22 | 1.47 | 1.33 | 0.85 | 00 |
| 2.6 | 2.55 | 6.45 | 7.8 | 00 | 0.39 | 0.73 | 1.02 | 1.23 | 1.51 | 1.39 | 0.90 | 00 |
| 2.8 | 2.40 | 6.60 | 8.4 | 00 | 0.40 | 0.74 | 1.03 | 1.24 | 1.56 | 1.45 | 0.94 | 00 |
| 3.0 | 2.25 | 6.75 | 9.0 | 00 | 0.40 | 0.74 | 1.03 | 1.25 | 1.61 | 1.50 | 0.98 | 00 |

## A NEW CONVERTIBLE DISCHARGE MIXER.

A new convertible discharge concrete mixer has been placed in the market recently by the Waterloo Cement Machinery Corp. of Waterloo, Ia. This machine is so arranged that it can discharge at the front, the rear, or on either side, without disturbing the trucks or moving it any direction. This is accomplished by removing four bolts in the turntable which is mounted between the truck frame and the I-beam frame of the machine. After turning the mixer frame with the chute pointing to any one of the four sides on which it is desired to discharge, the bolts are replaced and securely tightened, thus rigidly bolting the mixer frame to the truck frame, and the machine is again ready for business. The change can be made in less than 10 minutes. The accompanying illustration shows the four positions of discharge.



Four Positions of Discharge of New Mixer.

According to the Portland Cement Association, the roads, streets and alleys that have been placed under contract during the present year to be built of concrete, total nearly 23,000,000 sq. yd. Owing to many unfavorable conditions in the labor world, much of this work will carry over into next season. If the disturbing influences that have prevailed this year are absent in 1917, no doubt the new year will be a record one.

Water Works and Hydraulics Issue
of

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

Volume XLVI. CHICAGO, ILL., DECEMBER 13, 1916. Number 24.

## SOME COMMENTS ON LETTERS FROM CORRESPONDENTS RELATIVE TO THE UNION OF WATER WORKS SOCIETIES.

No suggestion made in these columns has brought forth more comment than our "get-together" editorial of Oct. 11. In our November Water Works and Hydraulic issue we published 18 letters and in this issue we publish 24 more, some against but more in favor of the union of the New England and the American Water Works Associations.

Mr. John C. Trautwine, Jr., voices, we believe, a sentiment to which the great majority of water works engineers and superintendents will subscribe, when he urges some sort of union not only of our water works societies but of all engineering societies.

It will be noted that several correspondents are averse to a consolidation of the two water works associations on the ground that each association is doing a good work now, and that there is no assurance that a union of the two would better the work of either one. Reasoning in matters of this kind must proceed by analogy. Were it established by experience that several independent local societies are more effective than one national organization, we should now have a large number of successful water works societies, for example, and an equally large number of independent local societies in every branch of civil engineering. Local civil engineering societies exist and perform excellent service, but there is only one national civil engineering society. The New England Water Works Association is purely local in name only. It is a national organization and its members are found in every state. Insofar as it takes on a local character because of its frequent meetings held in New England, it becomes akin to the local chapters of the national societies. Insofar as its papers and discussions are of nation-wide interest, it is akin to the American Society of Civil Engineers. Can it not join the American Water Works Association in such a manner as to merge its national features with the latter, while preserving its local features?

One of our correspondents suggests that if it were wise to unite two independent civil engineering societies it would be equally wise to consolidate two or more independent civil engineering periodicals. As a matter of fact, that is what has happened. Engineering and Contracting is itself a consolidation of four independent journals. The tendency in the field of technical journalism, as in all other enterprises, has been steadily toward such consolidations.

We believe that a much to be desired rivalry can be maintained among the secretaries of the local chapters of a national society, in building up membership, in securing good papers, and in promoting the welfare of technical men and engineers locally. Already this is being done by the local chapters of the American Society of Electrical Engineers.

In order to try out the feasibility of a union, why should not the two water works associations form a "federation of independent states," each preserving its name and identity, while joining under a common name for a common purpose? Let the name be the International Water Works Society, as suggested by Mr. Gwinn. Let the funds available for printing the papers be pooled, and let the transactions be published jointly.

If this were done, and if the international water works society were to make it one of its prime objects to take a hand in purifying municipal politics, water works management would soon become a profession more attractive because of the permanence of tenure, the opportunity to serve the public notably, and the high remuneration resulting from such service.

Pinhead politics and "graft" are the coal dust twins of municipal administration. We can not agree with our correspondent who, while deploring the fact, despairs of getting rid of these "twins" through any effort of any association of water works men. Who shall rid our cities of ignorant or grafting politicians if the very men who see its malign effects most clearly act as if they were the blindest to it? Water works superintendents and engineers have long enough scolded in private and kept silent in public about political maladministration of their departments. Let there be a general union of all water works men, first, for increasing technical knowledge, second, for the promotion of public and personal welfare through giving trained men complete control of our water supply.

## IRRIGATION BY PUMPING AS A FIELD FOR ENGINEERING PROMOTERS.

In our November Waterworks and Hydraulics issue we suggested that civil engineers should find a profitable field in promoting irrigation projects where pumping could be effectively applied. Large gravity irrigation projects have so engrossed the attention of engineers in past years that many have failed to realize that vastly greater areas can be irrigated by pumping than by gravity. Moreover, pumping projects can be undertaken on a relatively small scale, thus enabling many engineers to promote successful irrigation works of this character. Irrigation by pumping is being done in the very heart of this country, and therefore so close to the homes of capitalists that their interest can be easily aroused.

We shall publish, during 1917, a great deal of information relative to irrigation by pumping. Some of the information will not be new to some of our readers, for we shall abstract matter from various public documents, trade literature, etc. But we know that nearly all of it will be new to most of our readers. In any event it will be made available in such form as to save our readers a great deal of labor searching for it.

We hope to indicate to many engineers how they may so prepare themselves with knowledge about irrigation that they may be able to persuade capitalists to back them.

Several methods of promotion are available. A few hundred acres of land may be purchased outright and a pumping plant installed upon it. Then the land may be sold in small plots to farmers who receive their water from the central pumps. This plan works well where garden truck is raised on the land. Another plan involves the development of several hundred acres to be sold en bloc after it has been operated a year or so. A third plan involves the organization of a small irrigating company whose stock is partly or entirely sold to a small group of farmers whose farms are watered from a central pumping plant or plants. A fourth plan is to drill the wells and equip the irrigating plant under a contract with the owner of the land. The contract is preferably a cost plus a percentage contract, in which the percentage is forfeited to the extent that the actual cost exceeds the estimated cost.

Many engineers have already learned that one of the best ways to get good jobs is to make the jobs. Instead of waiting for some one to hire them for a salary or a fee, they fare forth and discover a place where a plant would yield a profit. Then they demonstrate the fact and secure the necessary financial support to carry out their plans. For that type of engineer the world will never be "too full of engineers."

In this issue we publish some interesting facts about the advantages of large (30-in. to 36-in.) wells and methods of sinking them.

## BETTER A LOAN TO THE MISSISSIPPI LEVEES THAN TO THE EUROPEAN ALLIES.

For nearly 40 years the Mississippi River Commission of army and civil engineers has existed, and during its existence has periodically pointed out the advisability of Federal aid in building a great levee system to protect the low lands of the Mississippi delta. Never was a more worth while project submitted for national support, with the possible exception of the Panama Canal. At half the cost of that great waterway the levee system can be completed, and, for an equal sum in addition, drainage canals can be built to reclaim 14,000,000 acres of now almost useless low lands in the great delta.

Half a billion dollars' credit was extended to Europe as a result of a few weeks' conference between American and European financiers. Doubtless such a credit was warranted. It has kept busy many a mill and many a farm and many a mine in America—for a short time. Let us consider what an equal sum would do if spent in the Mississippi delta.

Stretching from Memphis to New Orleans is an alluvial deposit covering 16,000,000 acres in area and of great depth. It is in fact a vast mine where for centuries the Mississippi has dumped the lime, the potash, and nitrates of its upper reaches. Here is a veritable "placer," whose nuggets are the minerals that plants may feed upon and transmit to gold. But the transmutation can be effected only under two conditions: First, protection of these lands from floods, and, second, drainage of the lower bottoms.

Already a vast levee system has been built in this delta without Federal aid, representing some $70,000,000, but the work has moved at snail's pace. While these levees have made possible the partial reclamation of almost 4,000,000 acres of land, every four years a great flood tops them and destroys millions of dollars worth of property. To give complete protection to these 4,000,000 acres and to make possible the reclamation of the remaining 12,000,000 acres of this delta, about 230,000,000 cu. yd. of earth must be added to the existing levees at a cost of less than $60,000,000, and then brush and stone mattress revetments must be built at an additional cost of about $80,000,000. Let us call it $150,000,000 for the levees and their revetments.

No experiment is involved in any of this work, for the methods of construction and the costs have been well established by the work already done. In fact it seems likely that if the work were done within a period of, say, five years, the cost could be greatly reduced; for, in that event, labor-saving machinery could be used on a large scale. We think it altogether likely that under those conditions the earthwork would cost less than 20 ct. per cubic yard, so that the levees alone would cost not more than $45,000,000. At present the revetment costs about $150,000 per mile, and as 700 miles of this will be needed, the present prices would entail a total cost of $105,000,000 for revetment. But, done on a large scale, the cost of the stone and brush for the mattresses would be reduced considerably, probably 20 per cent. Hence the entire levee system, including revetments that will make it permanent, can be built for about $125,000,000. This much the Federal government may well spend. Indeed we think it may wisely go farther and bulid the network of drainage canals that will be needed. These canals now cost about $8 per acre, which would make the cost of draining the 12,000,000 acres about $100,000,000.

Through its Reclamation Service the Federal government has reclaimed large areas of arid land suitable for certain kinds of vegetation, but the lands thus reclaimed are not adapted for cotton, for example. In brief, not only are the delta lands adapted to the growth of crops differing from those of the arid lands, but they are located in the very heart of the continent. The cost of the levees and revetments necessary to reclaim the remaining 12,000,000 acres of Mississippi delta lands will be about $10 an acre. Adding to this $8 for the drainage canals and laterals, and about $17 per acre for clearing off trees, gives a total cost of about $35 per acre for land that will be worth at least $50 an acre when thus improved.

An expenditure of $35 an acre on 12,000,000 acres would total $420,000,000, or less than the half-billion dollar loan to the Allies, and but slightly more than the cost of the Panama Canal. Can there be any doubt as to which investment would be most advantageous to America in the long run—a war loan or the reclamation of 12,000,000 acres of most fertile soil?

## ARTIFICIAL RAIN FROM ARTIFICIAL CLOUDS.

Artificial rain is obtainable, provided artificial clouds have been created. It may astonish hydraulic engineers to learn to what extent artificial clouds already exist. The writer was surprised when he began to make inquiry as to the use of what are called "overhead systems of irrigation," or the artificial rain systems.

One of the most widely used of these, "the Skinner system," is to be found in every state; for, contrary to popular impression, irrigation is required for maximum productivity even in the most humid parts of America. This system consists of a series of parallel, overhead pipes, provided with nozzles spaced 3 to 4 ft. apart. The pipes are designed to be rotated, either by hand or by power, so that the fine spray of water from the nozzles is distributed uniformly. An overhead system of this piping equipment (exclusive of the pumping plant and mains leading to the field) ordinarily costs about $100 an acre, but the increased output of garden truck, resulting from the frequent application of artificial rain, will usually repay the full first cost of the piping plant the first season.

For example, the Connecticut Valley Onion Co., South Deerfield, Mass., states that on a plot of 5 acres they doubled the onion crop as a result of installing overhead irrigation. Then they added 15 acres, and harvested 800 bu. to the acre, whereas the rest of the farm, which was not irrigated, averaged less than 500 bu. to the acre.

One of the improvements in this overhead system is the suspension of the pipes from small wire cables, thus greatly reducing the number of supporting columns. At a casual glance this arrangement looks like the "catenary system" of a modern interurban trolley line. In our January Waterworks and Hydraulic issue, illustrations and description of this novelty will be given, together with information about the automatic devices for continuous "oscillation" of the pipe lines during sprinkling.

The largest farm irrigated by "the Skinner system" is that of R. M. Kellogg Co., Three Rivers, Mich. There are 120 acres gridironed with overhead pipes, and served by a centrifugal pump operated by a 75-hp. electric motor. The pump has a capacity of 1,300 gal. per minute. Electric current is secured from the lines of a municipal power plant. Water is pumped from the river. The entire plant—overhead system, mains, pump, motor and building—cost about $30,000, or $250 per acre. Strawberries and cantaloupes are the only products of this farm.

The glimpse that this brief editorial has given of the successful application of artificial rain in humid climates, may serve to turn the attention of more engineers to this engineering problem. Certainly this is a field that has barely begun to be exploited in spite of the fact that overhead irrigation plants are by no means a novelty.

## EDITORIAL COMMENT.

The mining towns of Coolgardie, Kalgoorie and others in the Goldfields district of Australia are supplied with water that is pumped 330 miles. According to Mr. J. D. Birrell, in The Water Works Journal, 5,600,000 gal. per 24 hrs. are pumped through a 30-in. "locking bar pipe" against a total head of 2,700 ft. There are eight pumping stations and 20 Worthington pumping engines. The plant cost $12,500,000, which is an investment of $2,230,000 per million gallons of daily capacity. We believe this is, by all odds, the most costly water supply plant in the world. Estimating the fixed charges (interest and depreciation) at 8 per cent, we have a fixed charge of 50 ct. per 1,000 gal. exclusive of operating expenses. Water evidently comes high enough in Goldfields to make even a milkman think twice before using it as a diluent.

A business man who has been highly successful told the writer that he attributed his success to the fact that he had made it his constant business to keep informed on the progress of applied science. "Ignorance," said he, "is the best patent that a business man can have to protect himself from competition—the ignorance of the other fellow." If so, the vast majority of mankind is pretty well shut out of competition with the few who make it their business to keep abreast of scientific progress—provided the well informed few are alert enough to apply their knowledge. "Knowledge is power" only when applied. Engineering is the application of science, but relatively few engineers go forth into the byways seeking opportunity to apply engineering. Indeed, most of them stand around waiting for some fellow who is not an engineer to find engineering work for them. Defective engineering training accounts largely for this anomolous state of affairs.

Few men have learned how to schedule their work so as to achieve a maximum of success. Neither to the man who spends all his time studying what others have discovered or demonstrated, nor to the man who spends all his time "mixing" with others, does the greatest worldly sucess come. The confirmed student knows so few men that rarely does any man of affairs know that he is even well informed. The bookworm's chance of being hired for his knowledge is therefore rather slim. The confirmed "mixer" spends so much of his time getting and keeping acquainted that he rarely learns anything save what comes to him by word of mouth. Shouldn't the "mixer" type of man diligently hunt for a superior specimen of the "grind" type and force upon him the chance to acquire a large income through membership in the firm of Mixer & Grind? As a fact, several of the most sucessful partnerships in the consulting engineering field are of this alloy.

A thoroughly well balanced training for engineers would be one that would compel them to spend about equal parts of their time in three ways: (1) Going among men to acquire the power to influence them. (2) Studying what other men have discovered and invented. (3) Endeavoring to plan and carry through something to fruition. In so far as college life fails to give systematic experience along these three lines it is insufficient. Usually too much emphasis is placed on the second of the two kinds of training above named. It then devolves upon the graduate to train himself to be both a "mixer" and an executive.

Yes, "politics" is a much abused word, but politicians have so abused the public that who can now be seriously criticised for asking that "politics" be eliminated from water works management and other municipal affairs? If every organization of municipal engineers and superintendents of water works, streets, etc., will "jump in," graft politicians and ignorant politicians can be forced to jump out, fall out and stay out. But there will be no real "jumping in" until we all jump together.

## LETTERS TO THE EDITOR CONCERNING A UNION OF THE TWO WATER WORKS SOCIETIES.

It seems inconceivable that there can be any question of the eminent desirability of effecting as close a union as the practical men may find feasible, between the American and the New England Water Works Associations; but, as I read your editorial of Nov. 8, "A Proposed Union of the Two Water Works Societies," I found myself asking two questions:—First, "Why only these two associations? Are there not asteroidal state or sectional water works associations, in parts of the country other than New England, which also need gathering into the fold?" And, second, "Why only the water works associations? Why not all civil (non-military) engineering societies?"

I soon found my second question answered by your editorial, further on in the same issue: "Shall There Be a Federation of All Civil Engineering Societies?"

Why not?

The American Society of Civil Engineers (of which I am an associate) has in so far outgrown its "identity" hysteria of a dozen years ago as to be at least willing (and by a large majority) to dwell under the same roof with other national engineering societies.

True, this was accomplished only by assuring the more timid of its members that there was nothing in the cry (set up by some of the "stalwarts") that the step would mean a loss of some of its precious "identity" to the A. S. C. E.; but "the Civils" will shortly be finding that the other societies are not the dangerous neighbors that they were supposed to be; and they may then be in position to consider something akin to the bug-a-boo they feared; just as they have now shown themselves broader-minded than were their predecessors of that earlier day when their society could not bring herself to accept the hospitality of her sisters.

"The thoughts of men are widen'd with the progress of the suns."

And every real patriot—every man desiring his country's real welfare, and willing to use his gray matter to perceive upon which side that country's bread is buttered, will not only welcome Mr. Gwinn's suggestion that the greater society be called "International," but will insist that it be international.

Statesmen may continue to scheme for the undoing of the race by the perpetuation and the accentuation of international boundaries. Let engineers show that they have outgrown this childishness, and that they can clasp hands across these relics of a barbarism which, let us hope, is becoming effete.

John C. Trautwine, Jr.

Philadelphia, Pa.

I believe it would be of benefit to all if there was but one strong organization to cover the United States, Canada, and Mexico, and any outside communities which it would be of advantage to be associated with the main one on the northern part of this continent.

If the two old societies can't agree to eliminate one or the other let them select some new and appropriate name that will embrace all parts of the continent.

D. V. Bell,
Superintendent Water Cos., U. P. R. R. Co.

Rock Springs, Wyo.

If the interest of all water works associations could be conserved by one great national organization, it would of course be desirable to consolidate all such associations into one, but the very fact that there are a great many small water works the superintendents of which would like to attend the convention of water works officials, but cannot afford to do so, and which fact has called smaller associations into existence, like the Illinois, Central States and others, it would seem that there is a field for local associations, as well as one of a national character. These associations are intended to be helpful to its members and when any one of them cease to be so the latter will seek membership in the one which best meets that requirement. The time may come when the members of the two associations you refer to will find it desirable to consolidate, but the move must originate and find expression from among its members in order to be successful.

G. H. Benzenberg,
Consulting Engineer.
Milwaukee, Wis.

I have asked our sanitary engineer to state his opinion as to the desirability of consolidating the two water works associations. His statement is as follows:

"The advantages in the consolidation of the two water works associations must be apparent to all members of either or both organizations, and to all persons interested in water works. Consolidation will eliminate useless duplication. The economies effected thereby will enable the publications of the consolidated organization to cover the entire field more thoroughly than could be attempted by either organization at present. The data published by both organizations constitute two different sources of information to the public. The reports of any one committee in either organization lack at present the confirmation of the other organization. The interested public would be greatly benefited, not only from the point of view of saving time, but also by obtaining valuable authentic information, if these two organizations were consolidated."

Pittsburgh Testing Laboratory,
Director of Laboratories.
Pittsburgh, Pa.

It seems to me that your position in the matter of a consolidation of the two Water Works Associations is very appropriate.

I am a member of both societies and consider the Proceedings secured by my membership worth the expense. However, I see absolutely no reason why the two associations should not become one, and believe that the combined influence will be much greater than the divided influence of the two old societies.

W. R. Gelsten,
Superintendent Water Works Commission.
Quincy, Ill.

I have been a member of both of these organizations for several years, and feel that they should be consolidated. Under the present system, there is a considerable amount of duplication of Committee work; also a duplication of papers and discussions on important water supply subjects. I feel that since the American Water Works Association has authorized the formation of local sections, that the main argument against the consolidation has been removed. As I see it, the chief advantage that the New England Association has had over the American Association, is that, covering only a limited territory, it has been possible to hold frequent meetings, and hence, the members have become acquainted with one another, and the papers presented at these meetings have always called forth much discussion.

Since leaving New England, I have continued to belong to the Association, in order to receive the proceedings, but I feel that a single society would be able to publish a journal which would prove to be of greater value to water works' men, than the two now published. One national association of water works' men would be capable of fostering a greater expansion than two separate societies, and I trust such an association will be formed in the near future.

H. P. Lettey,
Sanitary Engineer, U. S. Public Health Service.
Chicago, Ill.

The editorial articles in your issue of Oct. 11, entitled "Competing Water Works Societies and the Resulting Loss of Efficiency" and "Why Have Two Water Works 'Shows'?" have been read with interest. They present an argument which might be unanswerable if certain conditions were different.

In the first place, there is a considerable overlapping of the membership. I do not know how many persons belong to both the American and the New England Water Works Associations, but it is probably safe to say that the number is between 100 and 200. Among the past presidents of the New England Association two have also held the presidency of the American Association. If consolidation were at present practicable these two men would naturally be found working for it; but such is not the case.

Next let us compare the histories of the two societies. The New England Association from the start has had from four to seven or eight meetings a year; until very recently the American had but one. The New England Association has published a quarterly journal almost from the beginning; the American Association has had such a quarterly only two years. The character and significance of the papers, discussions, and committee reports has also been materially different until within the last decade. Is it fair to expect the New England Association to merge with the American, at any rate until the latter has demonstrated that the "reformation" is permanent? and that the experiment of the establishment of the sections will in fact make possible all that independent existence has made possible to the New England Water Works Association?

Leaving such matters out of consideration, however, what would the members of the New England Association have to gain by merging with the American Association, becoming a local branch of the latter? If all the members retained their membership, they would belong to a larger and, perhaps, more influential society; and they would receive all the papers presented to all the sections of the association. On the other hand, however, the annual dues would be increased from $3 to $5; the headquarters would be (presumably) in New York, and much less accessible to the ordinary New England member; a large proportion of the conventions would be in such distant cities that there would be no possibility of his attending; and there has been a certain degree of domination of the American Association (particularly at its conventions), by the manufacturers, to which the New England members have been unwilling to submit in their own organization.

It will be urged that the men now holding duplicate membership will be relieved of one set of dues. This is true, but these are mostly professional men and superintendents in the large cities, to whom the additional payment is a matter of slight moment. The ordinary small-town superintendent would, however, feel the increase in dues from $3 to $5 as unreasonable, particularly in view of the other inconvenience or losses, and it is believed that a large loss of membership would result. If the consolidated society exceeded 1,600 in membership, even after several years of campaigning, it would be surprising.

There is some probability that at the present time a wholesome rivalry between the two societies, which are nearly equal in membership and perhaps in influence, is resulting in urging them both to efforts which would not be made without this spur.

But "Why Do We Have Two Water Works Shows?" Because it is one of the best ways in which manufacturers can advertise their goods. If the two conventions could be combined into one of double the size, so that the exhibits could reach twice as large a clientele with but little larger cost, it would, of course, be much to their advantage; but I believe that consolidating the societies and holding but one convention would not result in materially increasing the attendance. Rather it would mean that the manufacturers would nearly cut in half the audience before which their "show" is staged.

In short, mere consolidation would accomplish but little unless the local section experiment proves successful and the central organization can grow to really national proportions and representation, and this is largely a financial problem, as a brief consideration of the experience of other societies will make clear. The problem is the more difficult in that increase in dues means loss in members.

So far as the New England Water Works Association is concerned, were it to become a section of the American Water Works Association it would suffer increase in dues, with decrease in funds available to it to maintain its headquarters and to publish in full its transactions, for it has always been the thriftier manager of the two, and the more active organization. Mere consolidation of widely scattered units does not always benefit closely knit, well-managed local organizations, particularly if their experience and traditions have been different. As a case in point one might ask "Would not great gain result from an amalgamation of Engineering and Contracting, Engineering Record, and Engineering News?" What a subscription list there would then be, and how much larger a field the advertiser would reach! No subscriber would then miss any important article because he did not take all three papers, and he would get it all for the price of one! Yet I doubt if consolidation of these papers would be for the best interest of the public or of the individual.

Charles W. Sherman,
Consulting Engineer.

Boston, Mass.

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I have read with much interest your article on the consolidation of the two water works associations, and while consolidation is a good thing in many instances, it seems to me that if the two societies were united it might take away many very pleasant associations.

With so large a body of men and so few meetings in the year, it would have a tendency for members to lose their interest in it. Also the New England Water Works Association would lose some of its authority and brotherly feeling in a way. I have been a member of the New England Association for the past 17 years and have attended many of their meetings in Boston and received much good.

I believe in each society working for the best interest of each other, and for the betterment of all.

I should feel very sorry to learn that the New England Water Works Association was to be no more. It was a great work that those few superintendents got together and started years ago.

Let the good work that they started go on, for time has proved it to be all O.K. If it could be done, I should say that it would be a grand thing to eliminate politics, and the water works would be run in a more profitable way.

I should say for the present let well enough alone. My point of view may be considered one-sided, as I only belong to one society.

Frank B. Wilkins,
Superintendent Water Works.

Milford, N. H.

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Personally, I can see no real benefit to be derived by the mere consolidation of the two societies, the American and the New England Water Works Associations. To many of us, who find we cannot take a day off in the middle of the week, and travel 40 to 100 miles to attend the monthly meetings of any society, membership merely signifies subscription to another magazine; and the receipt of the monthly or quarterly proceedings is the only benefit we derive therefrom. Therefore, it signifies little to us as to whether there be one or a dozen such societies. The larger number simply gives us a choice as to which proceedings we prefer to subscribe.

This, to my mind, constitutes the greatest objection to one large society, to-wit, the meetings must of necessity be held at one place which is bound to be remote from the vast majority of its members. This prohibits their attendance, thus defeating the very aim of the large society—that of bringing many men into close fellowship.

It is proposed to alleviate this condition by means of local branches or chapters. This remedy certainly sounds attractive and these smaller meetings can be made very interesting and enjoyable. The main objection that I can see here is that small chapters or branches will not be able to secure the men for speakers or the papers for their meetings that a larger organization can. This, again, can be wholly remedied by a close, hearty and friendly co-operation between all the chapters, big and little; the larger ones contributing freely and gladly of their possible abundance to the smaller ones' probable scarcity. By doing this, all or nearly all—surely a larger number than at present—would receive that real benefit to be desired, that of "rubbing elbows" with, enjoying the good fellowship of, as well as comparing experiences with, his fellow engineers.

As far as the national society's taking an active part in eliminating politics from the management of city water works is concerned, I think every engineer should say, "Go to it!" At least I presume you mean by "politics" partisan or bad politics; for there are both good and bad politics. It has been rumored that even civil engineers have been known to use all the political subterfuges at their command to get a particularly attractive position. But possibly this is aside from the question.

J. A. Cushman.

Clinton, Mass.

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While common sense suggests one society with local chapters, nevertheless I am of the opinion that the best interests of the New England Waterworks Association will be served by a continuance of its present name and organization. Therefore if I am called upon as a member of that society to vote on the question of the union of the two societies, I will vote in the negative.

Richard W. Sherman,
Consulting Engineer.

Albany, N. Y.

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I have read with a great deal of interest the letters that you are now printing relating to a union of the two water works societies.

The writer is one of the younger members of both of these societies, having joined them since 1910. He has studied with care the papers that have been published in the proceedings, and has derived a great deal of benefit therefrom.

The Journal of the New England Water Works Association has papers containing a great deal of valuable matter that otherwise might not have reached the water works fraternity. On the other hand, if these matters can all be incorporated in the proceedings of one national organization, I believe that it would be of greater benefit than the present division into two publications.

It occurs to me that a union of the New England Water Works Association with the national organization might deepen the interest of the more local organizations. They no doubt have an "esprit de corps," due to local conditions and the contracting territory that is covered, that would be difficult to duplicate in a national organization. This spirit could be continued by provisions for local chapters, as some of the letters have suggested.

Personally, I would regret very much to see the Journal of the New England Water Works Association discontinued. On the other hand, if the two organizations can be combined and secure better results, I would favor such a proceeding.

F. L. Anders,
City Engineer.

Fargo, N. Dak.

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I have read your editorial on the union of the two water works societies, and also most of the letters from members of the two societies commenting on your editorial on the same subject.

With regard to the union of the two water works societies, I am personally absolutely and unqualifiedly opposed to the same. The New England Water Works Association has made for itself a name and place in this country which cannot be duplicated by any other society, and which I for one do not feel should be swallowed up or absorbed by any other organization. There is room enough in this country of ours for two such societies, and I can see no advantage in the proposed union.

I should regret it very much if the associate members decline to exhibit at either of the associations' meetings, but if they feel they cannot afford the expense of both, it is for them to decide which of the two is the more desirable to retain on their exhibition list. As has already been said, a great many of our active members attend the convention principally to find out and study what new appliances may have been brought out to help in the prosecution of their daily work; the papers that are read at our convention can be studied at their homes in the journal when issued. From some of the reports of sales made at our last convention in Portland, I do not believe many of the associate members will be inclined to abandon their annual exhibition at our September conventions. However, if such is the case, and it is a loss to us, we must bear it as best we can and satisfy ourselves with the intellectual feasts which are always obtainable at those meetings. I have many personal friends among the associate membership, and should regret very much their absolute withdrawal from our meetings, but if the firms which they represent feel that they cannot afford longer to continue showing their goods, I cannot feel that the New England Water Works Association can any better afford to allow its individuality and reputation to be absorbed by any other association now in existence or that may be formed in the future.

A. E. Martin,
Superintendent Water Department.
Springfield, Mass.

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I believe that the best interests of the water works branch of the engineering profession would be best served by one strong national society with local chapters. In my opinion, the national society should hold one, or perhaps two, meetings per year, and the local branches should meet as often as may seem most desirable to the members of the local branch, possibly once or twice per month.

Regarding the desirability of the national society taking an active part in eliminating politics from the management of city water works, I believe that this is most desirable wherever it can be effectively done. I believe that any engineering organization should take such steps as may be possible for the betterment not only of the interests of its members, but of the public at large, and surely the establishing of the practice of technical and professional employes of the city on the basis of their technical skill rather than their political affiliation is a step in this direction.

Elton D. Walker,
Professor of Hydraulic and Sanitary Engineering,
Pennsylvania State College.
State College, Pa.

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As a member of both societies, I see no reason why the union of these two important water works associations would not be productive of much good in promoting greater efficiency in the water works business of this country. "In union there is strength." Should these two societies unite under a different name with local chapters or sections throughout the country, I do not think it would be long before local associations would join, as all these associations seem to have a common aim and a common goal, namely, to attain greater efficiency in the management and service of the water utility. More definite principles could be established for the guidance of all water works. A national society with one journal could give to its members the product of the best thought and discussion on all vital questions concerning the water works business.

I think the national society should take an active part in eliminating "politics" from the management of municipal water works.

I believe the good it could do along these lines would be far reaching in its effect to educate the people to the fact that municipally owned water works, because of "politics," are often inefficiently managed and inferior service rendered at a greater cost to the taxpayer than private water works, although the demagog tries to make the people believe that the reverse is true. If municipalities were required to conduct their water works along the same lines as private water works and give a strict accounting of the cost, etc., there would doubtless be revelations that would change the prevalent opinion that municipal and government ownership benefits the people from the standpoint of efficiency and economy.

Certainly one national society would be more instrumental in bringing about such a reform than local associations in their limited spheres.

E. D. Bistline,
Secretary Lebanon Valley Consolidated Water Supply Co.
Newport, Pa.

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I feel it would be of considerable advantage if the two great water works societies of this country could be harmoniously merged together. These societies offer the manufacturer and consumer an opportunity to get together and exchange experiences to mutual advantage. In order to give all the interested parties an opportunity to discuss questions having to do with the manufacture of water works supplies, it is now necessary to take up these problems with each of the societies, which means a duplication of effort. The local chapters of such a national water works society would serve for the discussion of local problems and would lead up to more general discussion after such matters had developed into national importance.

F. N. Speller,
Metallurgical Engineer, National Tube Co.
Pittsburgh, Pa.

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It appears to me as a member of the New England Association that as the consolidation of the two associations demands their division again into local chapters they will finally be united in name and not in fact.

There is more interest now taken in the discussion of water works problems, and more effort made to solve them by the New England Association than there would be if that association became merely a chapter of a large and unwieldly organization.

No association of water works employes can eliminate "politics" from the management of city water works. Those who wish to reform or eliminate "politics" from public affairs usually wish to direct public policy as they think is best. Not until politicians cease to direct and control the national, state and municipal governments will they lose control of the minor divisions thereof.

The water works superintendent, manager or engineer should bear in mind that the management of his city changes frequently, and that such management has the right, as well as the power, to change the policy or the personnel of the department, and he should be prepared to seek other employment when he becomes persona non grata.

H. B. Macksey,
Superintendent of Public Works.
Woburn, Mass.

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I have read the editorial and letters in the November Water Works and Hydraulic issue on the projected union of the two societies and see that much has been said in favor of the suggestion as well as something against it. I do not know what the general sentiment is in the N. E. W. W. Association, of which I am a member, but speaking as an individual, I should say that the proposed union would be a step forward toward obtaining standard specifications for pipes, fire protection service, accounting, etc.

I am in favor of the N. E. Association continuing its own meetings and also publishing its journal, even if the more important papers from New England members were to be printed in the journal of the main society.

In regard to your second query I understand that as the word "politics" is in quotation marks that it means politics in a bad sense. Referring to a copy of Webster's unabridged I find that politics in a bad sense means "artful or dishonest management to secure the success of political candidates or parties; political trickery." Taking this to be the meaning in question I should say that the national society would be shamefully derelict in its highest duties if it did not take an active part in eliminating "politics" from the management of municipal water works. However, as the word politics in a good sense means "The science of government; that part of ethics which has to do with the regulation and government of a nation or state, the preservation of its safety, peace and prosperity, the defense of its existence and rights against foreign control or conquest, the augmentation of its strength and resources, and the protection of its citizens in their rights, with the preservation and improvement of their morals," I should say that the National Water Works Association might do well to take an active part in introducing the good variety of politics in municipal water works management and anywhere else where it appeared to be needed.

Frank S. Bailey,
With Stone & Webster Engineering Corporation,
Boston, Mass.
East Braintree, Mass.

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A combination of the New England and the American Water Works Associations would surely increase the efficiency and the economy of the work of the two organizations.

One organization could furnish a monthly journal to its members. This would be more easily done with a large membership, for a large part of the cost of publication consists in preparing the matter for press. After the matter is prepared for the press, copies can be furnished to additional members for the mere cost of printing. The equivalent of the two journals now issued could be sent to the members of the combined organizations for very little if any increased cost.

Except when joint meetings are held, meetings of the two organizations should be continued. The Illinois Water Supply Association, for example, has given up its identity to become a section of the American Water Works Association, but the members residing in Illinois wish to continue their meetings. Many of them find it impossible to spend the time to travel the great distances to attend all the general meetings. The sectional meetings provide near home an opportunity for men who have similar problems to get together.

Some plan for union can be devised in which both of these strong organizations can get together. Each can retain some interest in the name and in the organizations of a large association. Personally, I should like to see committees appointed by the two organizations to consider the union and to suggest a scheme under which union may be brought about.

Edward Bartow,
Director State Water Survey, University of Illinois.
Urbana, Ill.

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The union of the two large water works societies which you have so ably advocated in your recent editorials in Engineering and Contracting is a subject which merits serious consideration. Duplication of effort is wasteful and retards progress. However, no union can really be effective that does not have the sincere co-operation of both parties. Unless the ideals and objects to be attained in both organizations are alike, union will be of little or no value to either society. The euphonious phrases which may be found in their written constitutions and which purport to express the objects of their organization, do not necessarily indicate how well these ideals are lived up to.

A federation of the two societies might be possible without either one losing its identity. But a federated association needs able guidance in order to make possible true co-operation. The formation of local chapters may be advisable, but the creation of divisions into which the various phases of waterworks construction, operation and maintenance will naturally divide themselves, and the meeting of these divisions or sections at different periods of the year, seems to the writer a better plan.

Any candid observer in the waterworks field is bound to admit that considerable progress has been made during the last decade in reducing the bad effects of political interference in waterworks management, in spite of the fact that there are still with us many horrible examples. No one realizes so well as the waterworks manager the high price the tax and rate payers hand over annually, so that the great American game of politics may continue to be played. If those who foot the bills prefer to pay and growl rather than to bestir themselves and demand efficiency instead of inefficiency, what can the conscientious waterworks manager do except to utter protest against unbusiness like methods whenever opportunity offers. If he follows this course the time will come when he will be able to point to his record and say to the careless and indifferent layman, "I told you so but you would not listen."

You have my best wishes for your campaign of agitation and education.

J. W. Ellms,
Consulting Engineer.
Cincinnati, O.

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I have read with interest your editorial, "The Union of the Two Water Works Societies."

I am a firm believer in one national society with local chapters. These local chapters should more and more be conducted in the interests of the men actually in charge of the smaller water works plants. The criticism that these organizations have over-shadowed the average water works Superintendent has, unfortunately, a basis in fact. The national society should certainly take an active part in seeing that the management of city water works remains constantly in the hands of competent men, and that so-called politics are eliminated.

Alexander Potter,
Consulting Engineer.
New York, N. Y.

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Your article in the October issue on the union of the two water works societies, and your article on "Why Have Two Water Works Shows," are very timely and should have the earnest attention of the officials of both societies.

There is no question but that better results could be obtained through one national organization having geographical sections, and possibly state sections.

I believe that a single organization could get better results in the matter of eliminating politics in the management of city water works.

Walter P. Schwabe,
President Thompsonville Water Co.
Thompsonville, Conn.

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For a number of years I have been a member of both the New England Water Works Association and of the American Water Works Association, and it is my opinion that eventually the New England Water Works Association should become affiliated with the American Water Works Association. I do not believe that this can be accomplished at the present time as there are too many members of the New England Water Works Association who feel that on the basis of the record to date, the New England society has been of more service to the water works fraternity than the American association, and has, generally, set a higher standard both in its committee work and in the papers presented and their discussion. For the present, both the New England and the American associations should recognize that any attempt to produce standards, either in specifications, design or practice, should be the result of concurrent action. There certainly should not be two standards for the design of and specifications for water pipe and specials, etc.

Centralization is helpful, where it can be effected without eliminating or even reducing the interest in and work accomplished by local associations. Where dependence is placed either largely or wholly on volunteer service, many societies, each with its officers and committees, will generally accomplish much more than would a single large society made up of the individual members of the many smaller societies. The individual who gives his time, and frequently his financial support, to an organization in which he is an officer or a member of a committee, will seldom give the same thought and time to a large organization where he is simply one of the members. The American Association, through its formation of sections, provides a scheme of organization which preserves the advantages of the local associations with their officers and committees, and at the same time furnishes the central control which is necessary where action is to be taken on matters which affect the interests of many localities and sections of the country.

I believe, therefore, that there should be one national water works society, with local chapters, and that a feasible basis for the amalgamation of the New England association with the American association will be found.

As to the question, whether the national society should take active part in eliminating politics from the management of city water works, I find such a question is a good deal easier to ask than to answer. I think the society should use its influence toward eliminating politics from the management of city water works, but just how this can be accomplished, I am not now in a position to state. An open discussion of these questions such as you have started, is helpful, and will undoubtedly bring forth useful results.

Wm. W. Brush.

New York City.

I am much interested in your editorial suggesting the merging of the several water works associations into one national society and the comments of your subscribers thereon, and as a member of one of the present societies I think I can see some advantages that would come to the membership as a body by such action, and conversely there are perhaps some valid reasons against such a merging.

I assume that it will be granted that if a new organization is to be successful it must either meet an existing want or fill in better measure the public service that is now supplied by the existing societies. There are at present I believe two or three active water works societies and possibly other organizations that are working in this field, and, in fact, several of the state engineering societies give some attention to water supply and water works management. Both the New England and the American associations have each had a continuous existence of more than 30 years, and in that time the work of both societies has been of great service to their members and to the public at large, particularly within their respective field of influence, if that term can be applied to water works management, and has so far, I think, met the necessities for such an organization equally well as one national organization would have done.

The New England society by holding monthly or quarterly meetings, the session lasting but one or at most two days, has so far been able to secure a good attendance and to bring out and publish many valuable papers in its quarterly magazine, and has kept the per capita cost of membership within very reasonable bounds. As I am not a member of the American Water Works Association I am not so well advised as to its measure of success.

By a merger of the present societies there would be one large body of widely scattered members, extending from Panama to Alaska and from Maine to Manila, the individual members planning and handling municipal work over a very large field with varying climatic conditions, from torrid heat to arctic cold, and with varied labor conditions. Such an organization would of necessity have a central office in some city from which its affairs would be managed along lines similar to the present national engineering societies. It would probably hold one or possibly two meetings a year in the larger cities of the Union, lasting perhaps a week. The program would include, besides the usual grist of papers read, a number of junket trips or excursions to places of interest in the locality as additional educational and social features, highly appreciated by those attending. If the society published a weekly or monthly journal the papers with the discussions thereon, if any, would appear therein, otherwise the secretary would publish the proceeding in one or two volumes, each member of the society being entitled to a copy.

It is probable that the national society would secure a numerically larger attendance of members than either of the small ones, but, judging from my own personal experience, I question whether the percentage of total membership attending the meetings will be as great as the percentage of membership attending the meetings of the local societies, but the papers read may, and probably would, take in a greater range of subject matter, and in this respect there would be a gain by the merger.

The per capita cost of the one national society would probably be not greatly different than the present per capita dues in either of the existing societies. It is probable that the national society would be slow to commit its membership to settled public policies, but when such measures were adopted by the society unquestionably its action would carry with the measure much greater weight and confidence with the public than a like action by individual societies. The matter of personal prejudice mentioned by some member I believe is in most cases at least, more imaginary than real and the factor of politics in the management and control of municipal plants will not be greatly changed either way by a merging of existing societies.

Regarding the plan of holding the present local associations and others that may be formed as sub-units, with a general body exercising a sort of protectorate over them, about the only direct benefit I can see to the individual member that he would not receive from either of the smaller societies if managed as at present, or from the one national society if so organized by merging the local societies, would be the honor that would come to a limited few who would be representative delegates from the smaller societies to hold for a time a seat on the board of directors of the general body. The ordinary member, it is true, would have the privilege of writing after his name, "Member of Section A, or Section B, of the National Waterworks Society, United States of America." This might give the member social privileges or professional standing in some cases that he does not now enjoy, but in the element of cost per capita for benefit received I fail to see where the local member will be the gainer by this plan, if the local societies hold monthly or quarterly meetings as at present, and the grand body holds, say, one annual session and prints and distributes the proceedings of the local societies with its own.

Seth Dean,
Civil Engineer.

Glenwood, Ia.

From the standpoint of the small, privately owned water works, we would favor whichever plan gives us, in the official journals or in the trade publications, the greater amount of usable small-works data. The trade publications give the prompter reports, but we cannot take them all and therefore cannot be sure of getting the report that is edited for our requirements. We prefer the complete official journals. Another reason for preferring them is their better sized page. Of course, we take some of the trade publications also.

The United States is some big country, and America is bigger yet. The association that so spreads itself must take up many questions that are useless to us to the exclusion of some we want.

We want the opportunity to study the new exhibits and want the inspiration of the meetings and the personal touch with other water works men and so we attend the meetings within our reach, New York, Philadelphia, Portland, etc.

The present arrangement is excellent. The consolidation does not seem to promise any improvement for us.

As to "politics," that is a much abused word. You mean graft politics, bad politics, Republican politics (I am a Democrat). Yes, jump in and eliminate it. The Lord will be with you and we are with Him. Really, there's none of it in our company.

Wm. A. Wilcox,
President Waterloo Water Co.
Waterloo, N. Y.

## EMERGENCY CHLORINE INSTALLATIONS.

To the Editor: In your issue of March 1 you comment editorially on the little attention paid by the consuming public to the contamination notices sent out from time to time by water boards and utility companies.

It would seem, considering what is now known about chlorine as a sterilizing agent, the small cost of installation, and the ease of manipulation, that a water board that neglects to afford this means of protection for emergency use would lift from its shoulders but a small part of the responsibility, should epidemic follow, by merely sending out notices for the patrons to boil the water.

Liquid chlorine has much to commend it over the older chloride of lime treatment. More effective and positive as a sterilizing agent, and cleaner and simpler of manipulation, it has the further great advantage for an emergency installation of always being ready at the turning of a tap. The gas coming compressed to liquid form in the steel cylinders will suffer no deterioration though months or even years may elapse before there be need for treating the supply.

Towns and small cities seem to offer the most serious problem in the way of obtaining safe water supplies. Especially is this true if filtering or any sort of treating is resorted to. The superintendents sometimes not having either the facilities or the knowledge to make the tests themselves, and the city authorities not feeling disposed to make the necessary expenditure incident to the employing of a competent chemist or bacteriologist to attend to the taking of the samples and the making of the examinations, it often happens that it is not till an epidemic is well under way that suspicion is directed to the water supply. In many places there are manufacturing establishments maintaining laboratories of their own, and these, for a nominal charge, or in some cases merely for the interest in the health of their own employes, and without any charge at all, will make the examinations of the water, and so keep the system in order at all times. In any event it would seem that an emergency chlorine installation should be a part of every system not drawing its supply from a reserve from which permanent habitation is excluded, and over which the movements of individuals is under strict control.

### Irrigating Small Tracts.

In your issues of Aug. 9 and Sept. 13 you comment on the desirability of water commissions and utility companies encouraging their patrons to use water for irrigation, and you draw a contrast between the policy of these in trying to hold the per capita consumption down to a minimum, and the policy of the gas and electric companies which are ever and ever trying to sell more of their product.

The trouble seems to be that there is no way of irrigating a small tract in town without an inordinate waste of water or still more inordinate waste of time.

William Allen White in declining to leave Emporia to assume the editorship of a great New York daily is reported to have explained his action by saying that "There are, after all, few pleasures in life greater than watering your own lawn with a 25-ft. hose."

This sentiment is fine, and the expressing of the thought leaves nothing to be desired, but the fact remains that after watering the lawn on the first one or two warm evenings of early summer we, or most of us, decide generously to leave this particular pleasure to our wives, or to a 25-ct. sprinkler, which latter does effective irrigating for 15 minutes, and then proceeds recklessly to waste water until some one bethinks himself to move it along or shut off its supply.

I think it is safe to say that of all the crude ways left for doing things in this enlightened age when invention and adaptation has done so much to make life agreeable, none persists in its pristine crudeness to compare with the irrigating of a lawn or small garden in town. While the gas companies and the electric companies have been bestirring themselves to bring out new devices to do many things which before had been done in other ways, the matter of distributing water has gone on in the same way. Surely a fortune awaits the individual or corporation that can devise a system of elevated sprinkler heads, or depressed or disappearing sprinkler heads, which will, when not in use, be out of the way of the lawnmower, the whole to be under a system of remote control, say from a switchboard in the kitchen, so that one after another, or in series of twos or three, they will when once started, operate for 10, 15 or 20 minutes in succession until all the lawn shall have been irrigated. Until something like this is produced it would seem that the irrigating of gardens in town will continue to be an expensive proposition—expensive to the consumer if the service is metered, and expensive to the company or water board if no meters are used.

H. A. Rands,
Consulting Engineer.

Portland, Ore.
Oct. 27, 1916.

## LIME AS AN AID TO ALUM AS A COAGULANT.

Lime used as an adjunct to alum in the treatment of the Missouri River supply at the filtration plant of Council Bluffs, Ia., made possible the securing of a much better quality of water, and also was more economical than the use of alum alone, according to a paper by J. B. Thornell, chemist at the plant, presented at the October meeting of the Iowa and Illinois sections of the American Water Works Association.

The water is lifted from the Missouri River into the first group of three settling basins. Between basin No. 1 and Basin No. 2 is a weir 45 ft. long over which the water flows in a sheet about 3 in. deep. The lime and alum used as coagulants are added at this weir. The lime is applied through a perforated pipe extending over the entire length of the weir. The device for feeding the lime is located in the gate house near the weir. A large iron hopper is filled with dry lime. In the bottom of the hopper is a worm which pushes it into a smaller, funnel-shaped hopper below. A stream of water flows into the lower funnel dissolving the lime and carrying it out through a 2-in. pipe to the weir. A small electric motor drives the feeding device and is also attached to a small centrifugal pump which draws from one of the settling basins the water for dissolving the lime.

By an arrangement of pulleys and gears the speed of the worm may be regulated as desired. About 30 gal. of water are used for each pound of lime. The large volume of water used is one of the main factors in the success of the treatment because it completely dissolves the lime, thereby preventing clogging of pipes and bringing about thorough mixing of the lime solution with the raw water before it received the charge of alum solution.

The alum solution is applied through a second perforated pipe immediately after the lime solution. The amount of alum required varies between one grain and three grains per gallon and the amount of lime varies between one-half and one grain per gallon of water treated.

Comparison of the available data on the turbidity of the settled water and of the water at the point of application of the coagulants, and calculations of the cost of coagulants before and since the use of lime as an aid to alum was commenced shows that a much better quality of water has been obtained by the use of lime with the alum and that it is more economical than the use of alum alone.

## LEAKAGE FROM PIPE JOINTS.

Interesting statistics regarding the leakage from pipe joints were presented at a meeting of the New England Water Works Association on Nov. 8 by Mr. F. A. Barbour, Consulting Engineer, Boston, Mass. This matter supplements the information on this subject contained in the paper presented at the September convention of the Association and printed in abstract in the Oct. 11 issue of Engineering and Contracting. Extracts from Mr. Barbour's supplementary statement follow:

The fact that in entirely metered systems, or in systems where the meters exceed 85 per cent of the service, at last 20 per cent of the water furnished is, on the average, unaccounted for, does, however, stand out, and the question arises as to whether we should be content with such a condition. This 20 per cent loss is not based on a comparison of pump records with the water sold, but on the figures furnished by superintendents as to the water unaccounted for in their systems, these figures presumably making corrections for such items as pump slippage. It would seem that a loss of 20 per cent, due to leakage from mains and services or to under-registration of meters, which undoubtedly represents the best conditions, is sufficiently sizable to justify careful consideration of possible remedies.

We all know that the total unaccounted for water in unmetered systems is enormous; presumably we all agree that metering is the great remedy, and yet, as reported by the United States Department of Commerce, only 40 per cent of the services are metered in 201 cities, containing 26,000,000 people and having an average per capita consumption of 139 gal. per day.

The total population in the United States supplied with water from public works may be taken, for present purposes, at 50,000,000 people, and the average amount of water furnished per day at 100 gal. per capita. The total water supplied daily by public works is, therefore, in round figures, 5,000,000,000 gal. It is probably a safe statement that 50 per cent of this quantity is wasted, and assuming the actual cost of furnishing the useless 2,500,000,000 gal. to be $25 per 1,000,000 gal.—and this is an extremely low figure—the cost per day of the water wasted is equal to $62,500 or $22,800,000 per year, which is equal to the interest on an investment of $500,000,000.

As already stated, metering is the great means of reducing the total waste on which the previous figures are based, but there remains the fact that in the fully metered systems, on the average, at least 20 per cent of the water furnished is unacounted for, and probably if more accurate data were available this percentage would be shown to be materially greater. Emil Kuichling estimated 2,500 to 3,000 gal. per mile per day as the leakage from well-laid mains; Dexter Brackett estimated a leakage of from 10,000 to 15,000 gal. per day in the Metropolitan District; and John R. Freeman stated that his best guess of the underground leakage in New York was from 25 to 35 gal. per day per capita, equal to from 20,000 to 30,000 gal. per day per mile of pipe. In six cities, with 95 per cent of the services metered, reported by Brackett in 1904, 36 per cent of the water was unaccounted for, equal to an average loss of 11,300 gal. per mile of pipe. James H. Fuertes in the 1906 Report to the Merchants' Association of New York, presented statistics from 13 cities in which on the average 82 per cent of the services were metered, which showed that 31 per cent of the supply was unacounted for, equivalent to approximately 18,000 gal. per mile of pipe. What part of these losses is chargeable to the mains is unknown, but from the results of such leakage surveys as have been made, and from the reported actual losses discovered in some cities, it is probable that 7,500 gals. per mile of pipe per day is a conservative estimate of the water lost by leakage from the 60,000 miles of mains now in use in the public supplies of this country, or 450,000,000 gal. daily. At $25 per 1,000,000 gal., this is equal to a daily loss of $11,250 or $4,110,000 per year, or the interest on $100,000,000.

Are we taking sufficient care in testing pipe for water tightness when laid? About 60 per cent of those replying to the circular of the committee state that the pipe is tested when laid, and all but six make the test before backfilling. In the writer's experience, testing before backfilling in the ordinary work of laying distribution systems is rare, and it is undoubtedly from the practice of simply turning on the water without any test that a considerable part of the present leakage develops. The standard of those who test, as indicated by the replies received, is "absolute tightness," but in the writer's experience this result is not easy to obtain, and only possible where the joints are gone over several times after the pressure is applied.

Where pipes are backfilled before testing, the allowable leakage, as determined by such test, has varied greatly in different specifications. John H. Gregory at Columbus made the limit 500 gal. per inch mile per day. At Akron 200 gal. per inch mile per day was specified, while actual results at Akron showed about 70 gal. per inch mile per day. E. G. Bradbury, in his paper before the New England Water Works Association in 1914, proposed 100 gal. per inch mile per day as a reasonable standard for the allowable leakage in testing after backfilling, and he figured that the difference between 500 and 100 gal. per inch mile per day, estimating the cost of the water at $25 per 1,000,000 gal., would equal a yearly cost for water lost in a city of 100,000 people, of $5,256, or in other words, the city could afford to spend $470 per mile in order to save 400 gal. of leakage per inch mile per day.

Again, are the present jointing methods the best qualified to maintain tightness after periods of use? Who knows anything about the comparative leakage when laid and after several years? In this latter connection the history of the work at Grandview, O., is of interest. As reported by Mr. Bradbury, the supply is measured by a tested meter and all service pipes are metered. The 5.5 miles of pipe originally laid were tested before backfilling and the leakage before any connections were made amounted to 0.31 gal. per inch mile per day, or in other words, the system was practically watertight. Subsequently 0.9 miles of additional mains were laid, and gradually in the four years since the date of original construction the services have increased to the present number of 205. Either by less careful work in the extension or by depreciation of the original work, or by under-registration of the gradually increasing number of meters, the unaccounted for water has increased until at the present time it averages about 150 gal. per inch mile per day. An interesting feature in connection with these records is that the unaccounted for water, based on three years' observations, averages 60 gal. per inch mile per day during the six months from October to April and 213 gal. during the six months from April to October. In other words, the records indicate in this system that the unaccounted for water is three times as great during the summer as during the winter months. Whether some local explanation can be found for this result, or whether it is a reasonable result of temperature changes is not known, but data from other systems showing the unaccounted for water during periods of varying temperature would be of considerable interest.

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A. F. Barnes, Dean of Engineering of the New Mexico College of Agriculture and Mechanic Arts, State College, New Mexico, has been endeavoring to organize a Southwestern Engineering Society. Letters have been received from prominent engineers in the three states of New Mexico, Arizona and Texas expressing the need of such an organization. Among the men who have promised their support are Dean C. M. Butler of the University of Arizona, Tucson, Ariz.; Dean S. H. Worrell of the Texas School of Mines at El Paso, Tex.; Prof. Brenneman of the University of New Mexico, Albuquerque, N. M.; Mr. Samuel I. Bousman, engineer for the Chino Copper Co., Hurley, N. M.; Mr. H. L. Stevens, consulting refrigeration engineer, El Paso, Tex.; Mr. E. H. Baldwin of El Paso, Tex., project manager of the Elephant Butte Dam.

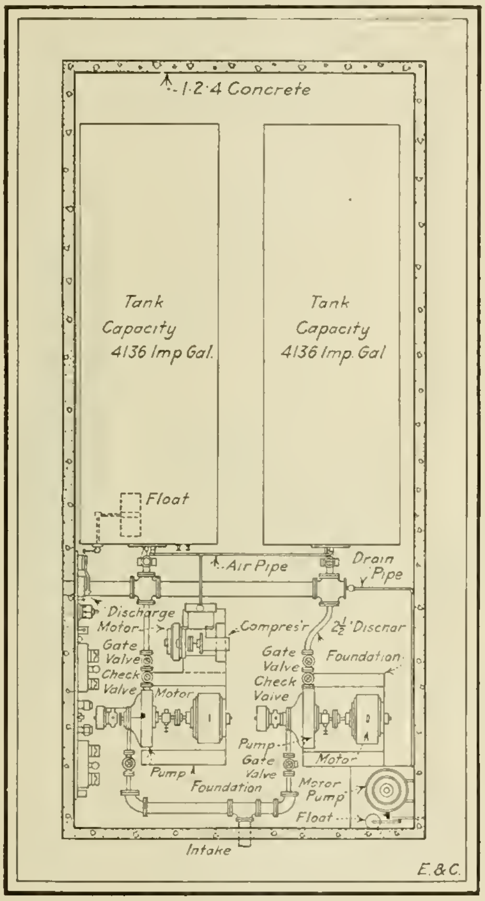
## LABOR COSTS OF CONSTRUCTING AN UNDERGROUND PUMPING PLANT.

Contributed by H. B. Ferriss.

The following costs represent the carefully kept and segregated items of cost connected with the construction of an underground pumping plant. In order to understand the records a brief description of the plant is perhaps necessary.

The company owns a subdivision for which it purchases water in bulk. The normal pressure as supplied to the company is satisfactory up to elevation 140 only. A considerable portion of the subdivision lies above this elevation, and in order to give adequate pressure to the purchasers within this high level district the pumping plant was constructed.

The engineer's original scheme consisted of the usual elevated tanks, etc., but was changed owing to the owner's set policy of placing all utilities underground. The plant, as finally approved by the directors, consists essentially of two electrically driven pumps connected to two large tanks; two motors operating the pumps; an automatic sump-pump and an air compressor with self-contained motors; all housed within an underground concrete vault. The sump-pump is mounted on an iron bracket fastened to the walls of the vault. The rest of the equipment is placed on raised concrete foundations, with the exception of the tanks, which rest on the floor, part of which was strengthened for this purpose. The plant is connected to large municipal mains and is entirely automatic in its operation.



Layout of Principal Equipment for Pumping Plant.

The vault housing the machinery and tanks is built of 1:2:4 concrete with a percentage of hydrated lime. The work was done very carefully in order to make the vault as nearly watertight as possible. The roof is 5 in. thick of reinforced concrete, supported on "I" beams. The floors are 6 in. thick, surfaced with 1 in. of 1:2 mortar, except under the tanks, where the floor is 12 in. thick. All openings for pipes, etc., were carefully caulked and the vault is considered practically watertight.

The excavation for the vault was in stiff white clay, and no timbering was required, nor was there any difficulty with water. The dimensions of the excavation were 18x38 ft. x 11 ft. deep, or 281 cu. yd., including the sump-hole. Of the total earth removed, 200 cu. yd. were backfilled, 150 cu. yd. were hauled to a dump 1 mile away, and 111 cu. yd. to a dump half a mile away, both hauls over good pavements. Two large boulders were removed during the work. The wagons were loaded as the earth was removed. Weather was good and the work very well handled.

The materials for concrete were delivered conveniently near the work, mixed on top at one end, and handled in wheelbarrows. After the forms and reinforcement were placed the walls were brought up in one continuous operation. The floor was laid first and special precautions taken to secure a good bond with the walls, which were built two or three days later. The workmanship was excellent.

A good foreman and well organized crew were employed from the first and it is believed that the costs on excavation and concrete are close, considering the character of the work.

The cost of installing the machinery, electrical equipment, etc., however, is regarded as high, as the men employed for this work were slow, although thoroughly competent and conscientious. Also there was considerable delay over the delivery of some special castings and other parts of the equipment. The company, however, was not affected, as the work was done under contract. It should, therefore, be mentioned that in the following costs the rates for this part of the work are assumed. The hours are correct.

LABOR COSTS OF CONSTRUCTING UNDERGROUND PUMPING PLANT.

Excavation (281 Cu. Yd.).

| | | Per cu. yd. |
|---|---|---|
| Foreman, 80 hr. at $0.50 | $ 40.00 | $0.14 |
| Labor, 570 hr. at $0.25 | 142.50 | .50 |
| Teams, 120 hr. at $0 70 | 84.00 | .30 |
| Blacksmith, 20 hr. at $0.30 | 6.00 | .02 |
| Backfill and clean-up, 55 hrs. at $0.25 | 13.75 | .05 |
| Total | $286.25 | $1.01 |

Note: Two extra dump wagons were included in the above rate of 70 ct. for teams, which were loaded while the teams were traveling. The unit cost for backfill only was about 40 ct. per cu. yd.

Concreting (57 Cu. Yd., Including Foundations).
Forms and Reinforcement.

| | | Per cu. yd. concrete. |
|---|---|---|
| Carpenter, 35 hr. at $0 40 | $14.00 | $0.25 |
| Helpers, 100 hr. at $0.35 | 35.00 | .61 |
| Common labor, 44 hr. at $0.25 | 11.00 | .19 |
| Total | $60.00 | $1.05 |

Foundations for Pumps and Motors—Concrete.

| | | |
|---|---|---|
| 43 hr. at $0.30 | $12.90 | $0.23 |

Walls, Floors, and Roofs.

| | | |
|---|---|---|
| Foreman, 12 hr. at $0.50 | $ 6.00 | $0.10 |
| Mixing, etc., 300 hr. at $0.30 | 90.00 | 1.58 |
| Tamping, 53 hr. at $0.30 | 15.90 | .28 |
| Miscellaneous labor, 20 hr. at $0.30 | 6.00 | .11 |
| Mix boards, etc., 10 hr. at $0.35 | 3.50 | .06 |
| Total | $121.40 | $2.13 |

Installation of Equipment.

| | | |
|---|---|---|
| Tanks (set in place by contract) | | $ 25.00 |
| Erecting all machinery, including water connections, etc.: | | |
| Skilled labor, 200 hr. at $0.50 | $100.00 | |
| Helpers, 240 hr. at $0 40 | 96.00 | 196.00 |
| Painting fittings and general clean up: | | |
| Helpers, 22 hr. at $0.40 | 8.80 | 8.80 |
| Erecting switchboard, wiring, etc., etc.: | | |
| Skilled labor, 192 hr. at $0.50 | 96.00 | |
| Helpers, 36 hr. at $0.30 | 10.80 | 106.80 |
| Testing equipment: | | |
| Skilled labor, 22 hr. at $0.50 | 11.00 | |
| Helpers, 22 hr. at $0.40 | 8.80 | 19.80 |
| Total | | $356.40 |

General Miscellaneous Labor.

| | |
|---|---|
| Haul machinery and supplies (other than concrete materials and tanks) | $37.50 |
| Seeding ground over roof or plant | 3.50 |
| Removal of tools, etc., and general clean up | 11.50 |
| Water connections for mixing concrete | 5.50 |
| Miscellaneous labor | 15.60 |
| Total | $73.60 |

The foregoing are all net labor costs only. Overhead inspection, etc., etc., are not included.

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The 500,000,000 acres of "improved farm land" in America average a crop of $20 per acre. Isn't it a joke to call such land "improved"? Let the drainage and irrigation engineer get busy on this land and note the real improvement that results—a several fold increase in productiveness per acre.

## METHOD OF REDUCING SEEPAGE LOSSES IN AN IRRIGATION CANAL THROUGH POROUS SHALE.

The main canal of the Grand Valley Project of the U. S. Reclamation Service follows for the greater part of its length along the lower edge of an area of shale hills and the wetted perimeter is largely in shale. These shales vary from a heavy dark blue to light gray. The latter is in more or less advanced stages of disintegration and in general is finely broken up by nearly horizontal seams and vertical fissures. In this condition it is very porous. The older canals in the Grand Valley experienced excessive losses of water in sections traversing this kind of material. In the December Reclamation Record Mr. J. H. Miner, project manager of the Grand Valley Project, describes the method employed and the results obtained in reducing the seepage losses in the Project Main Canal. Mr. Miner's article practically in full follows:

The prevention of excessive losses by percolation was given consideration prior to beginning the construction of the project main canal. Lining with concrete was not considered feasible, since these shales swell when wetted so that concrete lining might be expected to become cracked and inefficient. The protective measures adopted consisted in excavating the canal through shale to a depth of 1 ft. below the required grade, with a view of allowing silt to accumulate in this extra depth. When cleaning may be necessary the silt in this section will not be disturbed. At some points, where especially porous shale was encountered, the canal section was excavated with ½ to 1 side slopes below the normal water level, but the top width of the wetted section was not changed. In this way a triangular section was formed on either side of and outside of the required water section. These triangular areas were later filled with good surface soil crowded off of the top of the slope. Part of the earth lining was placed before water was turned into the canal and part afterwards. The work done with the water in the canal was the more effective in that the material compacted better and more quickly and also spread farther out on the canal bottom.

Earth lining or artificial silting was necessary, due to the fact that the Grand River carries very little silt. During 1915 the river was practically clear, and seasoning and priming work on the canal was performed at a disadvantage. During 1916 the river has carried an unusually large amount of silt. However, a sample of water taken from the canal at the headgates when the quantity of silt appeared to be at a maximum showed only one-fourth of 1 per cent of silt by volume. This silt is very finely divided, so that on inspection one is apt to overestimate the amount. In comparing the water of the Grand with that of the Colorado at Yuma, and the Rio Grande at San Marcial, N. Mex., it is found that the maximum of silt observed in the Grand River at Palisade was only 4¼ per cent of the maximum observed in the Rio Grande, and 14 per cent of the maximum observed in the Colorado.

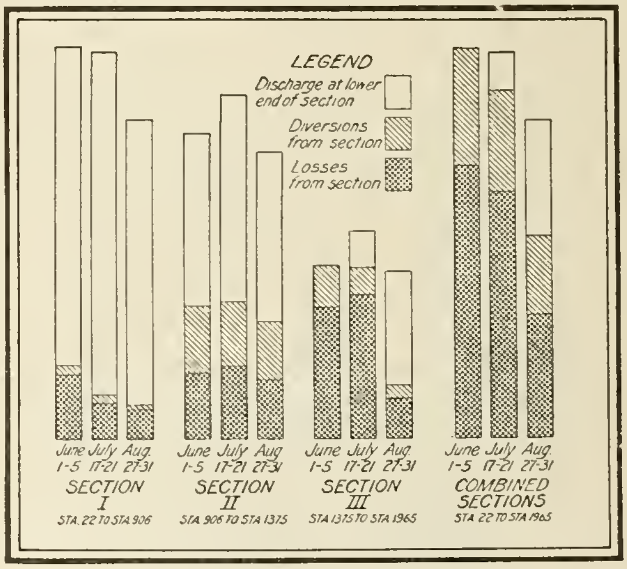
The local shales disintegrate very readily on exposure to air and moisture. Advantage was taken of this property by plowing and harrowing the shale portions of the canal bottom in the fall of 1915 after water had been run in the canal. The upturned shale was left exposed to the elements through the winter, and in the spring was again stirred with a heavy harrow to further assist nature in the breaking-up process. The shale has a tendency to break up in flakes that do not compact readily. A so-called "goat" was devised to hasten the compacting. It resembles a land roller, or pulverizer, except that the face of the rolls is provided with projections about 3 in. long, 2 in. in diameter at the tip, and spaced about 6 in. apart in each direction. The "goat" is hauled repeatedly over a given area and has the effect of trampling animals. It apparently made the canal bottom more compact, but no data have been secured to show directly what its effect might be in reducing losses by percolation. This "goat" was delivered but a short time before water was turned into the canal in the spring of 1916, and consequently it was used only on a small part of the canal length.

Data to show the effect of the operations in reducing conveyance losses have been collected for the three periods June 1 to 5, July 17 to 21, and Aug. 27 to 31, inclusive. These data have been computed for three separate sections of the canal and for the whole length of the canal that has been operated.

Section 1 extends from the upper gaging station at station 22 to station 906. This section contains only a small portion of shale, and the plowing and harrowing of this shale and the placing of earth lining were completed in 1915. The "goat" was worked in a portion of this in the spring of 1916.

Station 906 to station 1375 is a section which is perhaps 50 per cent in shale. This shale was plowed in the fall of 1915, and earth lining was placed in the late fall and early spring.

The section from station 1375 to station 1965 contains a still greater per cent of shale. This shale was also plowed in the fall of 1915, but not harrowed, and the earth lining in this section was placed during the run of water in the season of 1916, that beyond station 1850 being still uncompleted. Between stations 1100 and 1660 the canal was greatly benefited by silt brought in by a cloudburst on Aug. 13, which broke through the upper bank in a number of places. During the period from July 26 to Aug. 14 the Grand River water carried an unusually high percentage of silt, and as much of this water was taken into the canal as the conditions at wasteways would permit.



Observed Conveyance Losses from Main Canal, Grand Valley Project.

The tabulation of conveyance losses shows the following results, all losses being given in cubic feet per square foot of wetted area for 24 hours:

On the section from station 22 to station 906 the loss during the period June 1 to 5 averaged 0.557; for the period from July 17 to 21 this had been reduced to 0.248, and for the period Aug. 27 to 31 to 0.201.

In the section between stations 906 and 1375 the loss increased from 1.007 in June to 1.076 in July, and then decreased to 0.948 in the August period.

In the section from station 1375 to 1965 the loss increased from 1.94 in June to 2.118 in July, and then decreased to 0.588 in August.

The increase in the July period for the second and third sections was probably due to the fact that a greater quantity of water was carried through those sections in July and the upper edges of the wetted area had not become compacted.

The variation in the amount of loss in the three sections is further explained as follows: In section 1 all work was completed before observations were begun, and the improvement was due solely to the deposition of river silt and other natural causes. In section 2 a very small amount of work was performed during the period covered by the observations, and very little effect was realized from the river silt. On account of being unable to waste water from the canal without damage to property, it was necessary to so limit the volume of flow through the canal that low velocities obtained, and hence practically all the silt was deposited in section 1. The large reduction in losses in section 3 was due to the large amount of work performed on this section during the period covered by the observations and to the silt deposited by the heavy inflow of surface water during storms in the forepart of August.

For the canal as a whole the losses during the June, July and August periods were, respectively, 1,013, 0.923 and 0.481 cu. ft. per square foot of wetted area for 24 hours. The relative amount of the canal flow and losses for the three sections and the canal as a whole is shown graphically by the diagram.

As an extreme illustration of the results obtained from earth lining and silting, the observations made in the vicinity of station 1274 on the main canal, where the water prism is entirely in shale, are of interest. The canal is carried by a flume over a wash at this point and the bottom of the wash is about 12 ft. below the grade of the canal. Seepage appeared in this wash within 12 hours after water first reached this point in the canal, and continued to flow freely until earth lining was placed and fine silt chuted into a temporary contraction of the channel above this section. During the silting operations a sack dam was maintained about ½ mile down the canal to raise the water level 18 in. When the operations started the seepage flow down the wash, measured by a Cippoletti weir, was 2.45 sec. ft. The placing of earth lining immediately reduced this to 1.96 sec. ft. The artificial silting operations reduced the flow to 0.28 sec. ft., or about 12 per cent of the original flow. No further work was done at this point, but the effect of further silting by storm water, two months' flow of river water, and settlement of the earth lining still further reduced the flow to 0.053 sec. ft. In this instance the flow of free water was reduced 98 per cent. As far as can be determined, this loss from the canal occurred within a length of 1,500 ft., possibly within 1,000 ft. The free water therefore escaped from the canal before protective work was started at a rate between 5 and 7 cu. ft. per square foot of wetted area for 24 hours. This probably represents shale of the maximum porosity in this vicinity. Observations on a 2-mile length of canal in shale on which no protective work had been done has shown an average loss of 4 cu. ft. per square foot of wetted area for 24 hours. The present observed loss of only 0.48 of a cubic foot per square foot is thought to be very creditable. It compares favorably with the losses observed by Don H. Bark in rather impervious clay soils in southern Idaho and with the conveyance losses accepted by Etcheverry for all material except impervious clay loam and medium clay loam underlaid with hardpan. By local treatment at points of greatest loss it is expected to further reduce this average rate for the first 37 miles. The remainder of the canal is located too far from the headgates to receive any of the silt taken in with the river water, and in order to eliminate conveyance losses in this lower portion of the canal it is intended to install a silting plant, using pumps and a hydraulic giant to break up beds of suitable material and get it in suspension in the canal water.

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Monthly rainfall records at Providence, R. I., covering a period of 84 years are given in the last annual report of the city engineer. The records from 1832 to 1876, inclusive, were recorded under the direction of the late President Caswell of Brown University, and from 1876 to the present time at Hope Reservoir under the direction of the City Engineer.

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At present 87 per cent of the population of Ohio, residing in incorporated communities have access to public water supplies which are filtered or obtained from ground water sources, and the total population served by surface water supplies which are not filtered is only 200,000.

## EXPERIENCE AND RESULTS OF FOUR YEARS' OPERATIONS OF COARSE SCREENS, GRIT CHAMBERS, IMHOFF TANKS AND TRICKLING FILTERS AT ATLANTA, GA.

The city of Atlanta, Ga., is generally conceded to have one of the largest and best Imhoff tank and trickling filter systems in the United States. Owing to the topography of the city these disposal plants are required to handle the sewage. The Proctor Creek plant has a capacity of 3,000,000 gal. and was placed in service in August, 1912; the Peachtree Creek plant, 8,000,000 gal. capacity, was placed in service in September, 1913, and the Intrenchment Creek plant, 5,000,000-gal. capacity, was placed in service in June, 1914. The equipment of all three plants is substantially the same, consisting of coarse grate bars, grit chambers, Imhoff tanks, five screens or roughing filters and trickling filters. In a paper read before the American Society of Municipal Improvements at the Newark, N. J., meeting last October, Mr. Chas. C. Hommon, chemist and bacteriologist in charge of the plant, gave the experience and results obtained from the four years' operations. The paper, practically in full, follows:

**Coarse Screens.**—The coarse screens are of ¼-in. flat bar iron, spaced 1¼ in., center to center, and laid at an angle of 45° down stream. They have been very effective in removing from the raw sewage all floating material, such as dead animals, pieces of wood, tin cans, rags, etc., that might cause trouble if allowed to pass into the Imhoff tanks. The amount of screenings collected varies considerably in quantity, due to the fluctuations of rainfall and seasonal changes. There is always more after a heavy rain, the amount averaging (daily) about 30 lb. wet per 1,000,000 gal. As soon as collected the screenings are hauled away and buried, so as not to allow them to decay and create a nuisance.

**Grit Chambers.**—The grit chambers have done, and are doing, very creditable work in removing sand and grit from the raw sewage. The retention period of the sewage in the grit chambers is about 30 seconds, and with this period there is only a comparatively small amount of organic matter deposited with the sand. The sand dump pile has never been offensive, even in the warmest weather. Sand that is needed for the resurfacing of the sludge drying beds is taken from this dump, without washing. During 1915 the Peachtree Creek plant grit chambers collected an average of 0.6 cu. yd. of sand per 1,000,000 gal., and the cost of removal was 14 ct. per cubic yard, labor costing 15 ct. per hour. The sand deposited at the other plants ran considerably less, averaging about 0.2 cu. yd. per 1,000,000 gal., and the cost of handling averaged about the same as the Peachtree plants.

**Imhoff Tanks.**—The Imhoff tanks are of the circular type, 24.5 ft. deep, arranged in series of three, designed so as to give the sewage in the settling chambers a retention period of three hours, and are provided with crossover channels for reversing the flow. The tanks at all three plants have done excellent work, removing practically all of the settleable solids, and from 60 to 85 per cent of the total solids.

TABLE I.—AVERAGE YEARLY REMOVAL OF SUSPENDED SOLIDS BY IMHOFF TANKS, PARTS PER MILLION.

| | 1913 | | | 1914 | | | 1915 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ttl. | Removed. | %. | Ttl. | Removed. | %. | Ttl. | Removed. | %. |
| Peachtree Creek. | 109 | 54 | 49.5 | 120 | 62 | 51.6 | 145 | 86 | 59.2 |
| Proctor Creek..... | 238 | 182 | 76.2 | 402 | 338 | 84.0 | 328 | 282 | 85.8 |
| Intrenchment Crk. | ... | ... | .... | ... | ... | .... | 140 | 96 | 68.5 |

The greater efficiency of the Proctor Creek tanks over those at the other two plants is due largely to the reaction of the salts of calcium and iron from industrial wastes, whereby a flocculent precipitate is formed that assists in precipitating the colloids.

**Distribution of Sludge in Sludge Wells.**—As stated above, the tanks are arranged in series of three, and as the result of this arrangement one disadvantage stands out very prominently, namely, the unevenness of the deposit in the sludge wells. Apparently the bulk of the settleable solids is deposited in the first hour of retention, or while the sewage is passing through the first chamber, consequently the sludge well of the first tank receives more than its proportionate share of the settled solids, and the third well gets less. By reversing the flow at proper intervals the sludge level can be kept fairly constant in the two end wells, but this method of operation has little or no effect on the amount of material deposited in the middle compartment. As a result of this uneven distribution the end sludge wells are compelled to perform the work that should be done by the middle section, and the sludge storage period is thereby reduced. Thus far, however, this decrease in storage capacity of the sludge wells has not caused trouble at any of the plants, as the sludge from the end tanks has always been of a good quality. With good weather conditions it dries into good spadable material in from 7 to 9 days, if the sludge is not put on the sludge beds more than 8 in. deep. Recently the city closed a contract in which a local concern agreed to pay 15 ct. per cubic yard for the accumulated sludge, and to take the annual output at the same rate, from the beds. It costs approximately 15 ct. per cubic yard to remove the sludge from the beds, thus making a net return to the city of 30 ct. per cubic yard. It is understood that the purchaser contemplates using it as a filler for commercial fertilizer.

TABLE II.—AVERAGE ANALYSIS OF 36 SAMPLES OF SLUDGE COLLECTED FROM IMHOFF TANKS, ATLANTA, GEORGIA.

| Specific gravity. | Per cent water. | Per cent volatile. | Per cent mixed. | Per cent nitrogen. | Per cent ether sol. fat. |
|---|---|---|---|---|---|
| 1.02 | 87.05 | 39.1 | 60.9 | 1.25 | 6.11 |

**Formation of Foam and Scum in Gas Vents.**—The accumulation of scum in the gas vents seems to be a rather serious drawback of the Imhoff tanks in many places where they are in use, and there has been some trouble of this nature in the Atlanta plants. The first trouble was with the gas vents foaming or boiling over during the ripening period. The gases rising from the sludge well were encased in a greasy, tenacious film that did not burst readily, and the vents became filled with bubbles and foam and eventually overflowed into the settling compartments of the tanks. Spraying the vents with water under pressure was very effective for the time being, but they soon filled again. The free board was extended on one vent 8 ft. above the level of the sewage in the settling chambers, but in less than 24 hours the foam ran over the top and apparently would have gone higher, so this scheme was abandoned. Finally the plan of drawing practically all of the sludge from the wells and starting anew was resorted to and in a second trial the trouble did not appear to any extent. At the time the foaming was most troublesome at the Proctor Creek plant the Intrenchment Creek plant was under construction and it was thought advisable to enlarge the gas vents with a view of eliminating the above trouble. The central vents were made twice as large, increasing the total vent area by 33 per cent. During the ripening period at this plant the foaming was very troublesome and lasted for about six weeks, the larger vents seemingly having no beneficial effect in preventing the formation of foam.

On comparing the results of the larger vents with those of the smaller ones a rather interesting fact is noticed that the writer thinks worthy of consideration and further thought. In the case of the larger vents there has always been a heavy scum, sometimes as much as 4 ft. thick, while the smaller vents remained comparatively free. It is also true that even in the case of the smaller vents of the middle and furthest tanks from the inlet, where the gas effervesence is less violent, the accumulation of scum is greater than in the vents of the inlet tanks. In other words, where fermentation is most active there is the least accumulation of scum. It is also noticeable to a degree that more scum collects in the winter months in all of the vents than in the summer months when the gas production is greatest. It is the writer's opinion that the mechanical agitation due to the gas bubbles tends to break up the scum and release the gas entrained in it, thus allowing the floating matter to sink to the bottom. If this assumption is true, it appears that the smaller gas vent has a distinct advantage over the larger in that it tends to make the gas ebullition more effective in breaking up the scum.

TABLE III.—ANALYSIS OF GAS FROM IMHOFF TANKS.

| Source. | Methane. | Nitrogen. | Carbon dioxide. | Oxygen. | Hydrogen. | B.T.U. |
|---|---|---|---|---|---|---|
| Tank nearest inlet. | 72.5 | 5.7 | 2.6 | 0.0 | 19.2 | 838.9 |
| Tank nearest outlet | 50.6 | 4.6 | 31.0 | 0.0 | 13.8 | 586.9 |

**Utilization of the Gas Liberated from Imhoff Tanks.**—Utilization of the gas liberated from the Imhoff tanks has been in practice almost a year at the Peachtree Creek plant and has proven to be very practical as well as a financial success to the city. At present the gas is being used for all purposes in the laboratory and for heating and cooking in the chemist's residence. It is hoped that in the near future sufficient funds will be obtained for installing an exterior lighting system around the plant. Assuming that all the vents of the 30 tanks at Peachtree Creek are giving off gas at the same rate as from two we are now using, the whole plant is producing 30,000 cu. ft. per day, or 3,750 cu. ft. per 1,000,000 gal. of sewage treated. The volume of gas produced seems to be quite variable, due principally to temperature changes and the method of operating the tanks also seems to have a marked effect on the gas production. There is always a noticeable decrease just after drawing sludge.

**Fine Screens and Roughing Filters.**—It was thought at the time the plants were designed that it would be advisable to pass the tank effluent through a fine screen, or roughing filter, before admitting it to the filter beds, and a Weand revolving self-cleansing screen was installed at the Proctor Creek plant and roughing filters at the other two plants. It was found that they did not remove sufficient material to warrant their maintenance, so their use was discontinued. There is practically no material in the tank effluent that can be economically removed by fine screens or roughing filters, and it is the writer's opinion that with sewage similar to Atlanta's it is not necessary to screen the effluent from properly working Imhoff tanks before applying to trickling filters.

**Filter Beds.**—The filter beds have done exceptionally good work, considering the overloading they have been subjected to, when comparing them to current practice. The Proctor Creek plant is provided with 1.5 acres of filtering area, and was originally designed to handle 20,000 people, but the bed is actually operating at 100 per cent overload. This overloading is caused by the discharge of night soil from surface closets in the city into the Proctor Creek intercepter. By referring to Table IV it can be seen, however, that the effluent from the filter beds is of a very good quality.

The Peachtree plant is provided with 2.5 acres of filter beds, and there are approximately 80,000 people contributing to the plant. A part of the tank effluent is by-passed around the filters, however, and the beds are handling approximately 25,000 people per acre.

The Intrenchment Creek plant has 2 acres of filter beds and there are 50,000 people contributing to this plant, thus making 25,000 people to the acre.

Generally speaking, the beds at all three plants have remained in first class condition, with the exception of the early spring of 1915. During the winter of that year

TABLE IV.—YEARLY AVERAGES OF RESULTS ON ANALYSES OF TANK AND FILTER EFFLUENCES AT THE THREE DISPOSAL PLANTS AT ATLANTA, GEORGIA.

| | Free ammonia. | | Organic nitrogen. | | Nitrates and % nitrates. | | Sat. Dis. oxygen %. | | Relative stability. |
|---|---|---|---|---|---|---|---|---|---|
| | Tank Eff. | Filter Eff. | Tank Eff. | Filter Eff. | Tank Eff. | Filter Eff. | Tank Eff. | Filter Eff. | Filter Eff. |
| 1913. | | | | | | | | | |
| Peachtree .... | 11.4 | 6.3 | 5.8 | 2.7 | 0.3 | 5.9 | 13 | 78 | 89 |
| Proctor ....... | 26.0 | 9.9 | 9.0 | 3.8 | 2.2 | 8.8 | 33 | 64 | 96 |
| 1914. | | | | | | | | | |
| Peachtree .... | 11.5 | 4.4 | 5.2 | 2.9 | 0.4 | 6.5 | 9 | 69 | 97 |
| Proctor ....... | 25.4 | ... | 8.0 | 4.9 | 1.9 | 8.9 | 40 | 67 | 97 |
| 1915. | | | | | | | | | |
| Peachtree .... | 10.1 | 3.5 | 6.1 | 3.0 | 0.6 | 6.7 | 6 | 68 | 98 |
| Proctor ....... | 20.6 | 7.9 | 4.6 | 2.8 | 2.8 | 9.7 | .. | .. | 98 |
| Intrenchment . | 11.7 | 4.3 | 7.1 | 3.6 | 0.4 | 5.6 | .. | .. | 97 |

there developed a very heavy growth of algae on the Peachtree Creek beds, and in the early spring when it began to die and sluff off, the beds showed serious evidence of clogging. Finally the algae had to be picked off by hand. After removing the algae, the beds unloaded properly and were soon in excellent condition.

**Ventilators on Filter Beds.**—Several experiments have been made, from time to time, to prove the value of ventilators in the filter beds, but so far as could be determined they did not accomplish a great deal, and it is the writer's opinion that the results do not warrant the expense of putting them in.

**Sludge Drying Beds.**—The sludge drying beds are under-drained by 3-in. tile spaced 7 ft. apart and laid on a well-rammed clay bottom. The lower 10 in. of filtering material is of 1.5 in. crushed stone gradually grading to ¼-in. material, with a thin layer of sand on top. The surface of the Proctor Creek beds was made level while the Peachtree and Intrenchment Creek beds were put on a slope of 1 ft. to 100 ft. to facilitate the distribution of the sludge. The thickest sludge the Atlanta plants has ever produced contained 79 per cent water, and no difficulty was experienced in getting this sludge deposited on the level bed in an even layer. This being true, it necessarily follows that it is impossible to get an even deposit on the sloping beds. This is undesirable in that it causes uneven drying of the sludge, and thus reduces the capacity of the bed.

The net area of the Proctor Creek beds is 9,030 sq. ft. and was intended to handle the sludge from 30,000 people, allowing 0.304 sq. ft. per person, but in addition to this normal load, the night soil from approximately 30,000 more people from all sections of the city is discharged into this sewer. As a result of this over-loading only about 30 per cent of the sludge is dried on the beds. The remainder is run direct from the tanks onto lowlands surrounding the beds and allowed to dry.

The net area of the Peachtree Creek beds is 17,200 sq. ft. and the contributing population 80,000, thus allowing 0.22 sq. ft. per person. The area is entirely inadequate, and a good portion of the sludge at this plant also has to be dried on surrounding lowlands.

The net area of the Intrenchment Creek beds is also 17,200 sq. ft. and the contributing population 50,000, making 0.34 sq. ft. per person. These are the only beds that furnish adequate drying area. By careful manipulation and removing the sludge as soon as it is dry we have been able to dry all the sludge from this plant on the available sludge drying area.

**Odors.**—Very close observations have been made to determine the effect the plants have on the surrounding neighborhood, and the condition of the creeks below the entrance of treated sewage. The writer has never detected any noticeable odor except in the immediate vicinity of the plant, and to his knowledge there has never been any complaints made against the plants; all remarks being of approval rather than condemnation.

**Cost of Operation.**—The average cost of operating the three sewage plants during the year 1915 was $1.93 per 1,000,000 gal. treated, or 6 ct. per capita, assuming a population of 190,000. This figure, however, only includes actual operating expenses, such as supervision, labor, renewals, supplies, water and electricity, and does not include interest on investment or depreciation.

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The water distribution system of Providence, R. I., totals 418 miles of mains. During 1915 there were 35 leaks. Of this number 24 were in joints from unknown causes, 2 in joints caused by settling in sewer trench, 6 under railroad tracks, 1 in joint caused by pipe settling, 1 in face of bell caused by pin hole in casting, and 1 spigot cap blew off.

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The average cost of repairing meters by the Water Works Department of Cincinnati, O., including test charges, in 1915, was as follows: ⅝ in. meters, $2.55; ¾ in., $2.84; 1 in., $3.44.

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## THE ADVANTAGES OF LARGE WELLS FOR IRRIGATION AND METHODS OF DRIVING 30 TO 36-IN. WELLS.

Even among well informed hydraulic engineers we find relatively few who know that a well as large as 36-in. can be driven, and still fewer who are acquainted with the methods of driving wells of this great diameter. We question whether 1 per cent of the hydraulic engineers of the country could give a fairly satisfactory answer to this question: What are the economic advantages of a single 30-in. well over a group of 8-in. wells?

The best answer that we have seen to such a question, and the best description of the methods of sinking large wells, are given in Bulletin No. 141, issued by the American Well Works, Aurora, Ill. Accordingly, we have abstracted the following from that bulletin:

**Advantages of Large Driven Wells for Irrigation.**—From extensive experience in developing large capacity deep wells and installing pumping machinery for irrigation in all of the pumping areas in the Great Plains, the American Well Works recommends the following described type of well as being superior to any other now constructed for irrigation pumping.

The well should be as large as it is practical to drill, should extend at least 150 ft. into the water-bearing strata, if they are that thick, and should be the same diameter the entire depth. With the improved machinery now in use, it is practical to sink a drill hole in this area 30 in. in diameter. [Now 36 in.—Ed.] This permits the installation of a 26-in. steel well casing and a 24-in. deep well turbine centrifugal pump.

There are several important advantages in a well of large diameter the entire depth as compared with one that is of large diameter only to the depth at which the bowl of the pump is installed and has a smaller bore the remaining distance to the bottom of the well. If the well is reamed out to only a depth that will produce sufficient submergence for the bowl of the pump at the time the well is made, there is no provision for the future change of normal water head. If, from extensive pumping, the installation of additional wells, or protracted drouths, the water table is lowered it would be necessary to lower the pump to obtain the original quantity of water. This would require reaming out the well to greater depth, which would necessitate removing the well casing; always a difficult job and often a failure. If unable to remove the casing, the well would have to be abandoned and a new one drilled. By reaming the drill hole out to the same diameter the entire depth and casing it complete at the time the well is made, the pump can be readily lowered at any time and the well also has greater reservoir capacity. The first cost of the partly reamed out drill hole is less, as it requires less reaming and smaller pipe in the lower part of the well, but the large well the entire depth provides for the emergency, and since the success of well irrigation depends primarily on the ability of the well to supply, at all times, the required amount of water, the well reamed out to large size the entire depth is the only one recommended by this company.

**Casing and Screens.**—The well should be cased with heavy steel pipe the entire depth, either 10-gauge or 8-gauge, but preferably 8-gauge, and should be made into a strainer from the first water level to the bottom of the well, by drilling, or punching ⅜-in. round holes 1½ in. apart, center to center, throughout this length. That is, the surface of the pipe should be laid off in 1½-in. squares and ⅜-in. holes drilled in the pipe at the intersections of these squares, to form the strainer. There are a large number of patented screens on the market, some of which cost several times as much as a pipe perforated with round holes. We make the sweeping statement that all of these screens are relics of the time when it was considered necessary to screen the sand from the well, and none of them is as reliable, as cheap or as good for developing a well according to present practice as the well casing perforated with round holes.

The present method is to admit all possible sand into the well. No other construction will admit sand more readily than a round hole. In present methods of developing the well, where cavities are pumped out back of the well casing, the casing frequently is subjected to considerable pressure through material caving against it. No other construction will sustain this pressure so well as a solid pipe perforated with only small round holes. It has been a custom in several localities to install a length of patented screen opposite where the log of the well indicated each water stratum was located and use solid pipe for casing the remainder of the drill hole in the water zone. A comparison of logs of the supply well and test hole for the permanent well, usually only 20 to 40 ft. apart, of a large number of wells showed that very few of these logs agreed as to the exact location of the water strata. When drilling through several water bearing strata, it is evident that there is frequently a small water bearing stratum which is not detected by the well driller. It may be said, therefore, that when an attempt is made to screen a well only opposite the water bearing strata, it seldom, if ever, occurs that all of the strata are properly screened, with the result that there is a greater drawdown of the water than would be the case if properly screened, when the well is pumped at capacity. If the well is screened by having the casing perforated the entire distance from the first water stratum to the bottom, there is a free inflow from all the water bearing formations penetrated, and the smallest stratum contributing a trickle of water decreases the pumping head by just that much and correspondingly lessens the permanent cost of pumping.

**Location of Pump in the Well.**—When the pump is installed, the bowl should be located at the lowest pumping level with a suction pipe attached, extending to within 5 ft. of the bottom of the well. Pumps have been extensively installed in deep wells in the Great Plains with only 20 to 40 ft. of suction pipe. This method is cheaper than the one recommended, but it sacrifices a large part of the well. When a well is cased with coarse screen to admit the sand, any part of the well in which a current of water is not maintained will be rapidly filled with sand. From extensive observation, we make the statement that there is not a single large capacity, coarse-screened, irrigation well in the Great Plains which has been pumped for a considerable time that is not filled with sand to within a few feet of the suction opening of the pump. For this reason, there is little advantage in drilling any well in this area more than a few feet below where it is proposed to locate the suction opening of the pump. We have removed a large number of these pumps and never failed to find the well filled with sand to within a few feet of the end of the suction pipe. We have cleaned these wells and replaced the pumps only to have them again rapidly fill with sand and we have never succeeded in maintaining an open well until the suction pipe was extended to within a few feet of the bottom of the well.

As an illustration, we will assume a well 270 ft. deep with the water level 40 ft. below the surface when not pumped. It has been the custom, in many localities in this area, to allow 40 ft. for draw-down. If this allowance were made, the bowl of the pump in this well would be placed 80 ft. deep, and if 20 ft. of suction pipe were attached, the suction opening would be 100 ft. below the surface, which would leave 170 ft. of well below the opening in the suction pipe. With this installation, when pumping a large quantity of water and sand, the result always would be a well closed by sand to within a few feet of the suction opening, shutting off all the water from the lower strata. This is true of all localities where wells have coarse screens and receive water from sand formations, but does not apply where water is obtained in rock strata.

The objection has been made that by extending the suction pipe to near the bottom of the well, the head is increased by friction loss in the water passing through the long suction pipe. To offset this slight additional friction head, by pumping from the bottom, all of the water bearing formations are kept open, and there is a free inflow from the greatest possible area into the well, which is certain to greatly reduce the pumping head. With the entire well kept open, in this manner, well failure is practically impossible without lowering the water table to great depth, and should it be necessary at any time to lower the bowl of the pump, this can be readily accomplished.

If the suction pipe extends to within a few feet of the bottom of the well and the well is not pumped for a considerable time, the accumulation of sand around the suction pipe is likely to require forcing water down through the piping to start the pump, but if a short suction pipe is used and the well fills with sand up to this pipe, precisely the same conditions prevail.

It will be seen that the method advocated by this company not only produces a large reservoir to great depth, but develops both the entire well and all of the ground around the well, so that well failure is practically impossible without removing the last drop of water from all ground lying within economical pumping depth.

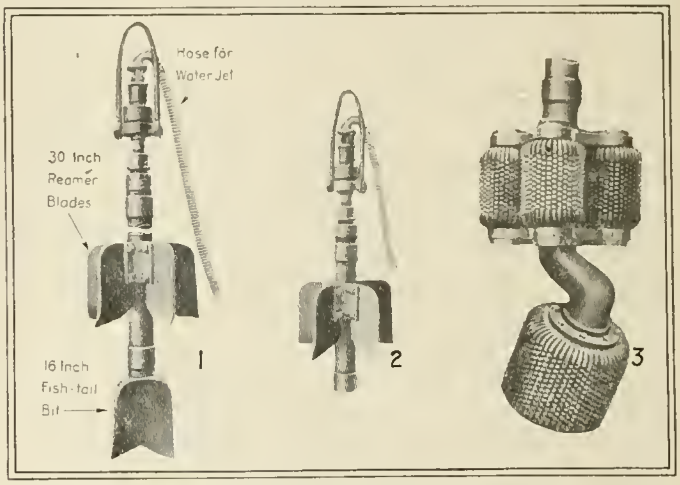

Fig. 1—Combination Fish Tail and Five Reamer Blade Bit. Fig. 2—Five Blade Reamer Bit. Fig. 3—Revolving Rock Cutter For Use In Hard Rock With Rotary Machine.

We firmly believe that if the methods advocated by this company for sinking, casing, screening and developing the well and installing the pump are practiced, there are millions of acres in the Great Plains that may be as certain of a full crop every year through supplemental well irrigation as any other area in America.

**Method Used for Drilling Large Capacity Wells in the Great Plains.**—The Texas Land and Development Co., using the improved drilling outfits shown in this bulletin, erect the derricks, put down the wells and case them complete in from eight to ten days; the actual drilling time being from three to four days. There are a number of operators attempting to sink large irrigation wells in this area with inadequate equipment who require from one to three months to complete a well. The working crew and cost for fuel with such an outfit are about the same per day as with the efficient equipment. The greater economy of operation with the most improved machinery will therefore pay the entire cost of modern equipment in the saving effected in drilling a few wells.

In the construction of a deep well irrigation pumping plant the first care should be to locate the well on the highest land to be irrigated. The work should then proceed with the idea that the well is a permanent investment, which, if properly made, will act as an insurance policy to guarantee a full crop every year and perhaps add several hundred per cent to the value of the land.

It should be borne in mind also that the success of the entire enterprise depends upon the ability of the well to supply the water. In some localities it is customary to sink two wells on large farms so that a pumping unit can be always kept in reserve in case of accident to well or machinery. Where two wells are installed, both should be on the high line of the land to be irrigated so that every acre can receive water from either pump.

Where a farm comprises a quarter section or less of land, the entire farm should be irrigated from a single well. It has been found that if the well is made of large size and properly screened and developed it will furnish ample water for 160 acres in the Great Plains and large engines and pumps are more efficient than small ones and a large irrigation pumping plant will require little more attention than each of several small ones. The seepage losses in the principal ditches will be greater with the large plant than where several small pumps are intalled to irrigate the same acreage, but this is more than offset by the greater economy of operation of the large pumping unit.

When the location for the well is selected the first operation is to drill a 6-in. supply well to furnish water for boiler and pump connected with rotary machine. This well is drilled only a sufficient depth to furnish the temporary supply required in making the larger well. A log is taken of this well to verify the log taken later of the 8-in. drill hole of the permanent well but as previously explained the larger drill hole furnishes the more accurate record. In this well a deep well plunger pump with a steam working head connected by steam pipe with boiler is usually installed. This pump delivers water to a tank for boiler supply and also furnishes water for the pool from which the drill pump obtains its supply. Some well drillers put down the test hole with the rotary machine in which case it is usually made eight inches in diameter and the permanent well is made by enlarging this hole. When this method is used, water must be hauled for boiler and to supply the pump with water for circulation.

The derrick is generally built 16 ft. square at base, tapering to 4 ft. square at top, the usual height being 42 ft. This derrick is very strongly constructed and is left standing as a part of the permanent equipment, by most operators, for use in case repairs are required to well or pump. The derrick is made with an opening on the side opposite the engine, through which the piping is taken.

The usual modern drilling equipment consists of a locomotive type steam boiler mounted on trucks; a steam engine, pump, drive shaft and cable drum shaft with the necessary clutches, brake band and feed worm gearing, mounted on a separate truck; tackle for suspending the drill pipe from the top of the derrick and the rotary machine mounted on the derrick floor, with the required connections for pump, cable and drilling tools. The engine is connected with counter-shaft on the same truck from which pump and main shaft are driven by sprocket chains and rotary machine is also connected with drive shaft by sprocket.

In operation the hoisting drum and cable are used to raise and lower the rotary tools or well casing. The rotary machine grips and rotates the drill rods or well casing and is so constructed that by loosening the grippers, the piping can be raised or lowered as required. The drill rod is usually 4-in. or 6-in. heavy wrought iron pipe and the lengths of pipe are joined together with strong taper thread couplings. The drill pipe is connected at the top to pulley block by a rotary swivel which has large roller bearings of high grade material and construction. This swivel is also connected with the water hose. The bottom of the drill pipe is fitted with a rotary drill tool or core barrel as conditions require. Sometimes the permanent well casing fitted at the bottom with a toothed steel cutting shoe is substituted for the drill pipe and is rotated down in the same manner. The core barrel is used only in cutting rock formations and the irrigation wells now sunk in the Great Plains are too large to successfully rotate down the permanent well casing without first drilling a hole. For these reasons neither of the above methods are used by the most successful operators in this area.

At Hereford, Texas, the test drill hole is made with the rotary machine. For this purpose an 8-in. fish-tail drill is used. When the test hole is completed, the combination fish-tail and 5-blade reaming bit, shown in Fig. 1, is attached to the drill pipe and the well enlarged to 30 in. in diameter. The fish-tail bit in this combination is 16 in. in diameter. At Plainview, Texas, the permanent well is begun with an 8-in. fish-tail bit and this hole is then enlarged to 16 in. in diameter with a diamond bit, and afterwards increased to 30 in. in diameter to 80 ft. from surface with either a combination fish-tail and 5-blade reaming bit or the reaming bit with pilot pipe shown in Fig. 2 and remainder of hole reamed with 16-in. reamer. The combination fish-tail and two rows of reamer blades bit has been employed in some instances for enlarging the drill hole, but the combination fish-tail and single row of reamer blades bit is now generally used for this purpose. When setting up the machine for operation care should be taken to see that the center of the opening in the rotary is in vertical line with the crown block in the top of the derrick frame. The rotary must then be firmly braced or bolted to the derrick floor to prevent its pulling out of line.

The suction pipe of the pressure pump is led into a shallow basin excavated in the ground close to where the pump is located. A trench is then cut by a round about way, to increase its length, from the center of the derrick where the well is to be located to the basin. The object is to make the circulating water travel a considerable distance in the trench before reaching the pool. This method allows the sand to settle in the trench from which it may be shoveled as the work progresses. The nature of the formation in which the drill is operating may be determined at any time by examining the sand as it is deposited in the trench.

The drilling tool for starting a large well is formed by connecting an 8-in. fish-tail drill with the lower end of a 6-in. heavy wrought iron drill pipe and attaching to the upper end a combination rotary swivel and hose connection. The water supply pipe from the pump is usually fitted with a three-way cock above which two pipes lead up the side of the derrick frame a considerable distance where connection with the water hose is made. This three-way cock and two-pipe connection permits joining up another water swivel to a length of drill pipe ready to be attached with least delay when it is required. The suction hose to the pump should be fitted with coarse strainer to keep out any material liable to obstruct the pump. The operator should test the pump to see that it is delivering normal volume of water before starting to drill and he should screw up all the joints in the drill pipe and fittings very tight as there is a certain amount of vibration in connection with the work which has a tendency to break the pipe threads if the joints are not tight.

When the string of tools is completed it is hoisted into the derrick frame by means of a cable led from cable drum, on the end of power truck, over crown sheave block at top of derrick and connecting with sheave block joined to swivel. The pump is then started and water passes through the drill pipe and is discharged through the two water orifices in the shank of the bit. The drill pipe is then gripped in the rotary machine and turned at a speed of 30 to 100 revolutions per minute, depending upon the size of the hole and the nature of the formation being cut.

As previously explained the methods used in enlarging the hole vary in different localities, but in drilling in soft formations the first small hole is nearly always made with a fish-tail bit. This bit will cut all kinds of soft material and many kinds of semi-hard formations, such as shale, gumbo and hard pan and also some forms of sand rock and cemented gravel or agglomerates.

When one length of pipe is drilled down to the machine the second length of pipe is screwed on. By using two swivels and two lengths of water hose in connection with the three-way water cock in the water supply pipe and onnecting up and hoisting a length of pipe into the derrick while the machine is in operation, the work of disconconnecting up and hoisting a length of pipe into the derrick water connection is accomplished in a few seconds and usually without stopping the pump. In running down the first length or two of pipe, it is necessary to watch closely to see that they do not get out of plumb. A derrick guide is used to hold the piping perpendicular.

The circulating water is usually allowed to become heavily charged with clay which is not only a natural result, but in many localities is essential to the success of the work. If clear water is pumped into a sand formation it will be rapidly absorbed by the sand and the circulation soon stop owing to the supply being lost in the sand. This is especially true when the sand is coarse and water bearing. The clay will not flow through the sand to a great extent and will materially help to stiffen up the walls of the drill hole and progress can be made faster through formations having a tendency to cave than by the use of comparatively clear water. This process is known as mud-walling a hole and is so effective that holes in pure sand are made to stand without casing for a considerable time.

When working through sandy formations there is a tendency of the sand to settle down around the drill when the water is stopped and in some cases considerable water pressure is required to lift this sand before rotating can be continued. In some formations the full weight of the drill rods may be allowed to rest on the bottom while in others it is necessary to sustain a part of the weight from the hoisting drum of the machine as the tools will cut faster than the pump will wash out the material. Experience will gradually indicate to the operator the amount of weight to carry on the tools.

When the drill enters a water bearing stratum, there will be a tendency of the water in the well to sink down to the ground water level. This indicates to the operator the location of each water bearing stratum. By using circulating water heavily charged with clay the water strata are quickly sealed to an extent that they do not interfere with the drilling operation.

In conditions especially favorable to this method of drilling and where proper equipment is used, the work progresses very rapidly. There are instances in which operating under very favorable conditions and where no hard formations were encountered 1,000 ft. of drill hole were made in a 24-hour day. This is unusual, but operating entirely in soft formations records of 200 to 300 ft. a day are frequently made.

If rock is struck which is too hard to be cut with tools designed for earth drilling it may be drilled by the rotary process by either using a core barrel and chilled shot or some form of revolving conical or cylindrical bit. The core barrel and chilled shot method consists of a core barrel of soft iron the size of the drill hole in circumference and any length required, but usually from 6 to 12 ft. long. This barrel may be used either with or without a shoe at the lower end. A slot is cut diagonally upward for several inches in the lower end of the core barrel, or if a shoe is used the slot is cut in the shoe. In operating by this method a core is made which when removed gives a complete log of the formations penetrated. The core barrel is attached in place of other tools to the lower end of the drill pipe and rotated in the same manner. Small irregular pellets of steel, usually known as "chilled shot" or "adamantine" are poured down the drill pipe, a handful at a time, and are carried by the circulating water and the slot in the lower end of the barrel down under the lower edge of the barrel, thus cutting the rock by abrasion. The barrel cuts a circular slot or "Kerf," leaving a central core. When several feet of rock are cut, if the drill hole is small, the core is removed by dropping a handful of stone chips down the drill pipe and wedging the core in the barrel so that it may be removed by drawing out the drill pipe. If the drill hole is large the core is taken out with special gripping devices which are run in to grip and lift the core after the drill rods are removed. Single pieces of core weighing over 1½ tons have been taken out in this manner from a drill hole 32 in. in diameter.

The revolving rock cutters used for cutting hard rock with the rotary machine are either conical or cylindrical in form with the surface composed of blunt teeth which drill by abrasion and the cuttings are washed out by the circulating water. The cylindrical form of this bit (Fig. 3) is so mounted that it has a gyratory motion and cuts both on the end and a portion of the side.

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## TESTS OF LEAD CAULKED PIPE JOINTS.

In connection with the construction of the new water supply system of Port Arthur, Ont., tests were made of lead caulked pipe joints. For this purpose some lengths of 12-in., 3/16-in. thick, 20 ft. long, bell and spigot steel pipe were used with a valve at each end of the line. The pipes were on blocking and standing free and in all there were four joints. A small hand pump having a displacement of 3 cu. in. free stroke was used. The results of the tests as given by Mr. L. M. Jones, city engineer, in a paper presented on Nov. 2 before the Canadian Society of Civil Engineers were as follows:

TEST NO. 1.

| Pressure, lbs. | Joint No. 1 run lead. | Joint No. 2 lead wool. | Joint No. 3 run lead. | Joint No. 4 lead wool. |
|---|---|---|---|---|
| 110 | Sweating slightly | Sound | Sound | Sound. |
| 125 | Sweating freely | Sound | Sound | Sweating slightly. |
| 150 | Dripping freely | Sound | Sound | Sweating freely. |
| 200 | Dripping freely | Sound | Sound | Valve started to move off, leaking freely. |
| 225 | Dripping freely | Sound | Sound | Valve moved off 2½ in., leaking freely. |

In the above test the protective solution was left on spigot and bell.

TEST NO. 2.

| Pressure, lbs. | Joint No. 1 run lead. | Joint No. 2 lead wool. | Joint No. 3 run lead. | Joint No. 4 run lead. |
|---|---|---|---|---|
| 110 | Sweating slightly | Sound | Sound | Sound. |
| 150 | Sweating | Sound | Sound | Sweating slightly. |
| 200 | Sweating freely | Sound | Sound | Valve jumped 1 in., and leaking freely. |

The spigot at joint was cut off and solution left on.

TEST NO. 3.

| Pressure, lbs. | Joint No. 1 run lead. | Joint No. 2 lead wool. | Joint No. 3 run lead. | Joint No. 4 lead wool. |
|---|---|---|---|---|
| 200 | Sound | Sound | Sound | Sweating slightly. |
| 300 | Sweating slightly | Sound | Sound | Dripping. |
| 350 | Sweating freely | Sound | Sound | Running. |
| 400 | Moved ¼ in. | Moved ⅛ in., not leaking | Moved ¼ in., dripping | Running freely. |
| 450 | Lead started to blow | Sweating slightly | Moved 1 in. | Running freely, but had not moved. |

Pipes were clamped in this test only, as shown in Fig. 1. At 450 lbs. the pipe buckled at joint No. 3.

TEST NO. 4.

| Pressure, lbs. | Joint No. 1 run lead. | Joint No. 2 run lead. | Joint No. 3 run lead. | Joint No. 4 run lead. |
|---|---|---|---|---|
| 200 | Sound | Sound | Sound | Sweating. |
| 275 | Sound | Sweating freely | Sound | Sweating. |
| 290 | Sound | Jumped ¼ in., dripping | Sound | Sweating. |
| 300 | Sweating slightly | Dripping freely | Jumped ½ in., leaked badly. | Dripping freely. |
| 340 | Sweating slightly | Dripping freely | Leaking badly and moving. | Dripping freely. |
| 390 | Sweating slightly | Dripping freely | Moved 1 in., lead started to blow | Dripping freely. |

The spigot ends of all pipes were well scraped and brightened.

TEST NO. 5.

| Pressure, lbs. | Joint No. 1 run lead. | Joint No. 2 run lead. | Joint No. 3 run lead. | Joint No. 4 run lead. |
|---|---|---|---|---|
| 150 | Sweating slightly | Sound | Sound | Sound. |
| 200 | Sweating slightly | Sound | Sound | Sound. |
| 225 | Sweating freely | Sound | Sound | Sound. |
| 250 | Sweating freely | Sound | Sound | Sound. |
| 275 | Sweating freely | Sound | Sweating slightly | Sound. |
| 290 | Sweating | Sound | Jumped 3/16 in. | Sound. |
| 340 | Sweating | Sound | Moved ¾ in., lead started to blow at bottom | Sound. |

In this test 1¾ in. to 2¼ in. of lead were used in each joint instead of from 2½ in. to 3¼ in. during the previous tests.

The foregoing tests were made within a few hours of making the joints, and in order to ascertain what advantage there would be in leaving the joints for several weeks, a test was conducted four weeks later on pipes caulked when the above tests were made. In this test three joints were caulked with lead wool and the fourth with lead wire $\frac{3}{8}$ in. in diameter. When the test was applied the pressure was gradually raised to 500 lb. per square inch with no preceptible sweating. When raised a few pounds higher one of the joints suddenly moved $1\frac{1}{2}$ in. The arrangement of pipe was similar to the previous tests.

One test was also applied on a 24-in. pipe as above, there being four joints in all, caulked with run lead, lead wool and lead wire. When the pressure reached 120 lb. the run lead joints gave out. On account of cold weather no further tests were made.

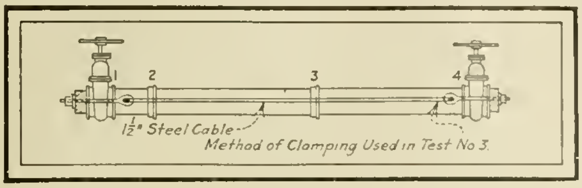
1
2
3
4
$1\frac{1}{2}$" Steel Cable
Method of Clamping Used in Test No 3.

Fig. 1.

It should be noted that the pressure exerted on the 12-in. gate at 500 lb. per square inch, was 56,550 lb., and on the 24-in., 54,286 lb. and 120 lb. pressure.

Some points brought out in the tests according to Mr. Jones' paper were:

1. It is evident that lead wool makes a better joint than run lead and lead wire better than lead wool.
2. That a depth of lead from $1\frac{3}{4}$ in. to 2 in. from the face of the bell is cheaper and just as efficient as a greater depth. Caulking had no effect on the lead beyond this depth.
3. The clean spigot allows of a better joint being made than one having a covering of solution.
4. That the run lead joints gave better results when pressure was applied about four weeks after making, than immediately after being made.
5. That none of the lead blew from the joints until considerable movement had taken place in the joint.
6. That better results would have been obtained had the pipe been laid in the trench and properly covered, for the reason that no movement would have taken place in the pipes if bends were anchored.
7. It is evident that all bends of considerable angle should be anchored to prevent movement. This was very clear with regard to the 24-in. pipe.

## PRESENT STATUS OF MIAMI FLOOD CONTROL PROJECT.

On Nov. 24 the court rendered a decision approving the plans of the Miami Conservancy District of Ohio, thus bringing this $17,000,000 project one step nearer the construction stage.

The engineering work is well advanced and the plans for the project have been completed. There is still considerable engineering work to do in the preparation of contract and working drawings and in the collection and classification of data for use on the appraisal of benefits and damages.

The most important work on this project just now is the preparation of the appraisal record which will set forth in detail the benefits and damages acruing to each particular piece of property in the district, from the proposed construction. It is expected that the Board of Appraisers will complete this work within the next two months, and, after the Conservancy Court has approved this appraisal, the Board of Directors will be ready to issue bonds and let contracts for the work. It is therefore possible that construction may be started some time during 1917.

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The Water Works Department of the city of Youngstown, O., has adopted the lime method of precipitating iron from the Mahoning River water and at the same time softening it before turning the water into the city mains for public consumption.

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## THE PREVENTION OF SLIDES ON THE PANAMA CANAL.*

In October, 1915, the President of the United States was advised by a member of the National Academy of Sciences—which was organized by an act of Congress to give expert advice to the President and Congress on scientific matters—who stated that one of its members had made an extensive study of earth slides in tropical countries, and was convinced that there were relatively simply ways by which they could be stopped, and suggested that a committee of mining engineers and geologists of the academy be appointed to consider his propositions. In consequence of this, the President of the United States requested that a committee be appointed by the National Academy of Sciences to "Consider and report upon the possibility of controlling the slides, which are seriously interfering with the use of the Panama Canal." From the correspondence it appears that at a meeting held in New York, "* * * the hope was repeatedly expressed that an effective solution may speedily be found."

The coming of the committee was welcomed on the Isthmus, for so much misinformation had been sent broadcast, doing more injury to the canal than the closing of it by the slides; confidence had been upset; and it was hoped not only that a remedy would be forthcoming, but that the report of the committee would be able to restore confidence in the project, especially as those connected with the work knew that the methods adopted would overcome the difficulties for good and all, given the time and money, and that the waterway would be all that had been expected.

The preliminary report by the committee of the National Academy of Sciences was submitted to the President in January, 1916. At that time they expected that their final report would be completed in April, but up to date it has not been received. The committee expressed the belief that every available and practicable device for controlling the water, both on the surface and underground should be employed, and to this end advocated covering the slopes with vegetation to prevent surface wash, closing peripheral cracks, draining undisturbed and threatened areas, and draining by tunnels.

For several years the expedient of covering the slopes with vegetation has been carried on, starting under the direction of Dr. Pittier, of the Smithsonian Institution. Where the surface of the ground is in motion, as in the case of active slides, the roots are disturbed, and the steady growth of vegetation is impracticable. Trees and vegetation of all kinds growing on the surface of the ground which broke in October, 1914, were carried down the slide and exercised no deterring effect whatsoever. On sliding ground there is not sufficient time to plant anything and no good would be accomplished. Where the banks consist of the red clay of the country, it is only after considerable difficulty that grass of any kind can be grown on them. Vegetation stops erosion; on this account the work was undertaken and is being carried on.

When peripheral cracks occur in rock with sufficient earth covering they may be effectually closed by the use of a hydraulic grader, as was done in an incipient slide on the west bank of the canal near Las Cascadas. The sluicing down of the earth into a uniform slope not only fills the cracks and prevents the access of surface water into them, but facilitates the drainage by providing a ready means of run-off into the canal. This method, while applied with good results at the north end of the East Culebra slide, so long as the material is at rest, a subsequent movement develops new cracks and irregularities so that until all loose clay and rock is removed and the final slope reached, the relief is temporary only. Where there is very little earth covering, as is the case on Culebra Hill, and where the cracks are wide and extend a great depth in rock, it is not practicable to close them permanently without expense that is disproportionate to the results obtained.

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*From the annual report of Gen. Geo. W. Goethals, Governor of the Panama Canal Zone, made public on Nov. 20.

In compliance with the expressed wishes of the committee while on the Isthmus, subsurface tile drains have been installed within an area on Culebra Hill as an experiment. Also, as suggested by the committee, the fault fissure under the hard Obispo tuff on the north side of Contractors Hill has been sealed and a concrete-lined drain constructed, draining the surface water into the canal, with a view to the protection of the Cucaracha rock beds adjacent to this portion of Contractors Hill.

It is admitted that if the water could be entirely excluded the earth movements would cease, but unfortunately this is impossible. With the heavy tropical downpours the best that can be done is by drainage, to carry away what falls as rapidly as possible, but ground water can not be eliminated. So far as concerns ground water, the construction of the canal has created entirely new conditions. The old tributaries of the Chagres River and those of the Rio Grande, which formerly were natural drains, are now well above the water surface of the canal, and the canal has become the drainage channel for the country for miles on either side. Even assuming that were it possible to devise a system for getting rid of ground water, it must still exist below the surface of the water in the canal itself. The slides in question affect the banks for a considerable distance down, probably below the bottom of the canal, and if ground water be primarily the cause, then it can not be removed from the strata at which the trouble starts.

Surface drainage was maintained throughout the period of dry excavation. The adjacent country on either side of the canal was drained through the east and west diversions, which continued to act as drains, discharging their accumulated waters into the Chagres. In relieving the pressure, force pumps on barges have enabled the washing down of part of the material, as already explained. The hydraulic grader which was constructed in July, 1914, and put in commission in August, 1914, was built especially for opening channels to expedite surface drainage at various points along the line of the canal, and to maintain them, and this work has been carried on, although suspended south of the slide, due to the interruption and shut-off of the channel last fall and winter.

So long as the slides are active and the configurations of their surfaces change as rapidly as they now do, it is impracticable to open and maintain the permanent drains recommended in the moving areas. When equilibrium is restored, and as a means of promoting permanent stability, the drains of a permanent character should be constructed and maintained.

Drainage by tunnels has been considered in connection with data obtained since the committee's report was written, as the result of experiments suggested by the chairman of the committee, Dr. Van Hise, through whom the services of Prof. Warren J. Mead of the University of Wisconsin, were secured, and who was assisted by Mr. Donald F. MacDonald in making tests of the rock formation in which the east and west Culebra and Cucaracha slides have occurred. The result of the experiments in brief were as follows:

> Twenty-one average samples of the Cucaracha or sliding formation were taken from below the water level of the canal. These samples, completely saturated, contained 12.20 per cent of water by weight, or 27.8 per cent of volume. The 16 average samples taken from well above the level of ground water, where the rocks were much jointed and fractured and, therefore, perfectly drained, contained 10.60 per cent of water by weight. As shown above, 12.2 per cent of water by weight fills all of the pore spaces of the rock; therefore, 10.6 per cent by weight fills only 87 per cent of them, leaving 13 per cent of the total pore space as having been emptied by drainage and by drying. Now, 13 per cent of 27.8 per cent is 3.6 per cent of the total volume of the rock. This shows that natural drainage of the most perfect kind would not remove more than 13 per cent of the water by weight, equivalent to 3.6 per cent of the volume of the rock. However, most of the samples from the drained rock were taken very close to the surface, so that very likely they lost some of their water through drying out by the heat of the sun, for the dry season was more than a month old at the time they were collected.
>
> These facts show that while the sliding rocks have a high percentage of pore space, the pores are mostly of capillary size and are filled with water which obeys the laws of capillarity and which can not, therefore, be drained off. These experiments definitely established that all cures by drainage which had been offered to and urged on the canal authorities were absolutely futile, and the money which might have been wasted in worthless tunnels, wells, and acres of asphalt covering, was saved for the only remedy that could bring permanent cure under the circumstances—dredging.

Before considering the suggestions that have been made for controlling or preventing the slides other than those already mentioned, it may be well to state what was attempted by the canal forces in this direction prior to the occurrence of the slides which are now active.

During the excavation of the Cut 22 slides and breaks of various extent occurred. The steps taken to protect exposed slopes by vegetation has been noted. It was believed that piles driven through the loose material into firm ground below and tied at the tops might check the movement, and this was tried at four of the slides, but without success. In some instances the piles were carried bodily down the slope; in others the underlying material, moving faster than the upper portion, inclined the piles away from the Cut, and in cases where the top surface moved faster than at the bottom, they inclined in the opposite direction. The remains of these piles can be seen at the present time in some of the areas so treated.

It was thought that in case of clay slides heavy riprap dumped on the surface would find its way through the loosened material to firm ground and check the movement, but this method was found as useless as the piling. Most of the riprap rock was taken out at the foot of the slope as the excavation proceeded. Experiments were made by concreting the face of the prism to prevent the disintegrating effect of the air on some of the softer rocks; this was done by use of a cement gun, by plastering the surface with cement mortar and by reinforced concrete, anchored to the side of the prism with pieces of rail. None of these methods was satisfactory or durable. The remnants of the French drains, which proved inadequate, were dug out at the bottom of the prism. The conclusion was reached that the only cure was the removal of all loosened material as it came into the Cut, and in case of breaks to relieve the weight, where possible, from the upper parts of the banks by steam shovels or sluicing operations.

In considering any method for stopping the slides some conception must be had of the enormous amount of material involved, as well as the method in which it acts. The banks at present giving trouble are from 300 ft. to approximately 550 ft. above sea level, and extend back 1,300 to 1,800 ft. from the faces of the prism, and from these farthest points to the water surface the entire mass is broken for a depth extending at least to the bottom of the canal. The movement is by fits and starts, sudden at first and gradually subsiding, with renewed activity after a period of quiescence. For instance, in August, 1916, a general movement occurred at the east Culebra slide and consisted of a settlement from 20 to 25 ft. vertically down at the rear portion of the area affected, some 1,300 ft. from the prism, by which a mass of material from the lower part was projected into the Cut beyond the center line, reducing the depth of water along this line an average of 5 ft. Because of the width of the new channel, as well as the depth, navigation was not interrupted, but some idea may be had of the enormous amount of material that must be held back by any artificial construction or device similar to those which have been proposed, and the impossibility of their construction must be recognized.

Suggestions most frequently made have been along the line of sowing vegetation and of properly draining the area. These have already been considered. To sink a number of pipes and apply steam for drying out the subsoil would be prohibitive on the score of expense, even if it were practicable. It would be impossible to drive and hold such pipes through the material in case of motion. Pipes sunk for the purpose of pumping out the water are equally impracticable and impossible. From the experiments conducted by Prof. Warren J. Mead and Mr. MacDonald all the water could not be extracted by this method. Piling the entire area at regular intervals and tying the piles to anchors driven in the firm ground can not be done, nor would it secure the result anticipated by the proposers of this scheme.

The construction of retaining walls would require the excavation of material to secure the foundations, necessitating the removal of all the material in motion, when the need for the retaining wall would no longer exist. There is no form of construction that could be designed that would hold back the superimposed mass while the excavation for the foundations was in progress. The construction of inverts to hold down the bottom of the prism is impracticable and impossible.

Wire netting rolled over the bank and held in place by stakes would not prevent the movement, but would seriously interfere with the dredges in removing the material littered up with sections of wire mesh, which would break loose with every movement of the slide. Consolidating the mass by injecting grout would also be impossible; the pipes could not be driven to firm ground below and the earth and rock, as it now comes into the Cut, can be much more easily handled than would be the case were this material solidified by cement.

It was suggested that the slopes and the surface of the ground adjacent to the Cut be covered with asphalt, tar, or some preparation which would exclude water from the ground. This was also proposed by a member of the committee from the National Academy of Sciences. That the committee did not include it among its recommendations seems conclusive that in its opinion it was not practicable, and no further comment seems necessary.

The methods proposed for securing a channel through the slides and to maintain it, adopted in October, 1915, were laid before the committee of the National Academy of Sciences, including the sluicing operations proposed on the west side, but no suggestions were made which modified the plan in any way. The various propositions made by a number of people seeking to help us in our troubles were carefully considered, as were also the theories advanced setting forth the probable causes. There were a number of letters, the writers proposing, for suitable monetary consideration, to cure the slides, but these were filed. None of the suggestions or theories tended in any way to change the plans adopted.

The dredges did their work so well that a channel was cut through the Isthmus connecting the two banks, of sufficient size to pass the small ships still tied up and awaiting transit. By April 15, 1916, a sufficiently stable channel had been secured to warrant opening the canal to navigation, and the transit of shipping has continued to date. Except at "Gibraltar" the waterway is 500 ft. wide with 40-ft. depth over the greater part, this depending on the movements that occur in the banks. So far as the Culebra slides are concerned, the worst is over; the intervals between movements are becoming greater and the quantities of material less; the only danger being at "Gibraltar," but it is hoped that the excavation continued along the lines contemplated will enable the widening of this section to the adopted prism line without interfering in any way with the transit of shipping. The reopening of the canal was at the beginning of the rainy season, and thus far the rainfall has been above the normal.

The recent movement at Cucaracha was, as usual, the unexpected, coming as it did from the high ground in the northeast corner of the slide area. The difficulty attending this was not a question of amount of material, for the dredges could cope easily with the movement on this score; the hard flinty rock was difficult to break up, and caused irritating and aggravating delays.

As predicted at the time the great Culebra movements occurred, the slides will be overcome finally and for all time, notwithstanding the calamity howlers and in spite of the disastrous predictions of the "know-it-alls."

## THE WORK OF THE COUNTY SANITARY ENGINEER.

In 1911 the General Assembly of Ohio passed an act authorizing boards of county commissioners to provide for the construction of sewers outside of municipalities. This act authorized the establishment of sewer districts which should form the territorial unit for sewer benefits. In 1913 another law was passed superseding the one of 1911. Lucas County up to the present has been the only county to take advantage of the act and create a Sanitary Engineering Department. The work of the department was outlined by Mr. L. A. Boulay, sanitary engineer of the county, in a paper read at the August conference of Ohio Health Officers. The matter that follows has been taken from Mr. Boulay's paper.

Some provisions of the 1913 act are as follows:

A sewer district is established by resolution of the County Commissioners, and may be any part of the county lying within three miles of and outside of any incorporated municipality.

Each district "shall be designated by name and number and shall consist of one or more main, district or intercepting sewers, together with the necessary lateral or connecting sewers and treatment works."

The Board of County Commissioners are empowered also to "lay out, establish, maintain and operate a sewer and sewage treatment works inside or outside such district for the purpose of conducting sewage from such district to a proper outlet, and for the purpose of properly treating such sewage."

These sewer districts may be established by the County Commissioners, and such action is frequently the result of complaints of nuisances, filed with the County Sanitary Engineer, or by petition from various property owners in that territory, desiring to have a district established.

To supervise the work of the commissioners they are empowered to employ a competent Sanitary Engineer, or in a county having a population exceeding 100,000, to create a Sanitary Engineering Department. (The Act of 1911 only authorized the employment of an engineer for such time as was necessary to prepare plans and superintend construction, the compensation not to exceed $10 per day.)

After the establishment of a district the Sanitary Engineer makes the complete topographic survey of the district and determines upon some general plan of drainage, which, when completed, is reported to the Board of County Commissioners for approval, and, if approved by the board, is forwarded to the State Board of Health at Columbus, for its approval of the general plan of drainage and general method of disposal of the sewage collected.

After the approval by the State Board of Health, the commissioners may proceed with the construction of any part or the whole of the proposed system, as planned. They may proceed of their own volition by declaring, by a majority vote, the necessity of the sewer or sewage treatment works contemplated. It is more usual, however, for the commissioners to take this action as the result of a petition by a majority of the freeholders of the acreage lying within the territory benefited by the main sewer, or by petition of the majority of the freeholders of the frontage benefited by a local sewer, or by the order of the State Board of Health.

When the assessment is confirmed by the commissioners, it becomes final, and remains in the office of the commissioners 30 days for the purpose of receiving cash payments on it. After the expiration of 30 days, the board may issue bonds for any unpaid portion of said assessment, after which it may enter into contract for the construction of the improvement on the basis of competitive bids. These bids must be advertised for in a newspaper of general circulation in the county for not less than two or for more than four consecutive weeks.

Of the cost of the improvement, the county's share amounts to at least 2 per cent of the total cost of street intersections, and this is provided for in the annual levy made up by the budget commissioners, upon estimates furnished by the County Sanitary Engineer.

To summarize very briefly the work of the Sanitary Engineering Department, as authorized by this Act, a short list of the duties is given below:

1. The preparation of preliminary plans for the drainage of a district, or the treatment of sewage collected.
2. The preparation of detailed plans, specifications, estimates of cost and assessments to cover the property share of an improvement.
3. The supervision of the construction and recommendation with regard to the final acceptance of the work.
4. Subsequent maintenance or operation of the improvement.

At present the Lucas County Sanitary Engineering Department has two rooms in the Court House: one a general office and one a drafting room. A very complete laboratory is also maintained.

The office force consists of:

1. The sanitary engineer-in-charge.
2. An assistant engineer.
3. Assistant engineer and chemist.
4. A chief clerk.
5. A stenographer.
6. A draftsman.
7. A transitman.
8. Two rodmen.
9. Inspectors as construction demands. At present there are five.

The laboratory has a complete bacteriological equipment, including incubator, autoclave steam sterilizer, hot air sterilizer, microscope, necessary glassware, etc. It also contains all apparatus necessary for complete chemical analysis of water or sewage and apparatus for gas and air analysis.

For the past six months the cost of running the department has been on an average of $1,818.31 per month, divided into $1,371.25 per month for payroll and $447.06 per month for supplies, water rents and other expenses.

As much of the payroll and other expenses as is directly chargeable to any special sewer job is charged to that job, and assessed against it, so that it has only cost on an average of $450 per month for overhead to maintain the department, and this money is spread on the general tax of the county.

Considering the large amount of work at present handled by the department and the greater amount to be handled in the future, it is nearly self sustaining.

There have been established six sewer districts, two of which have been combined into one. The territory under the control of this department, as regards sewers, embraces a three-mile strip of land, entirely surrounding the city of Toledo, and containing in the neighborhood of 35,000 acres. This is a larger acreage than is contained within the city limits. The total territory, including Toledo and the other municipalities in the county is 175 square miles.

Up to the present time, approximately, 30 miles of sewers have been built or are under construction, the cost approximating $200,000, or on an average of $6,600 per mile. This would include about 8.5 miles in West Toledo which has since been annexed to the city of Toledo.

During the coming twelve months sewer work to the amount of $600,000 is under contemplation, which will include new districts and trunk sewers and laterals in existing districts.

The month following the establishment of the department, the commissioners combined with the office of Sanitary Engineer that of Inspector of Nuisances. It was felt that in this way one organization would suffice for the work of both offices, and that the duties of these two offices were so closely related that they could be best taken care of under one head.

It has been the practice of the department to make investigations and analyses of well water upon request of the owner and at no cost to him. Up to the present time it has been kept very busy with design and construction of sewers, and it has been impossible with the present force to make any general survey of the wells, except upon request.

Two general pollution surveys have been undertaken; one of Sibley Creek which receives considerable domestic sewage and slaughter house wastes. The object was to study the effect of bloody wastes upon a small stream. The conclusions reached were that because of their very high putrescibility, bloody wastes will cause a greater nuisance and that more quickly than the same volume of domestic sewage. Where sewage is disposed of by dilution slaughter-house wastes should be first treated, unless the diluting volume is extremely large, and even here local nuisances may very easily arise.

The other investigation dealt with the water supply of Point Place, a summer colony on the northwesterly shore of Maumee Bay. Point Place derives all of its water supply from wells. These vary from deep drilled wells to shallow excavations in the sand with the familiar kitchen pump on the end of a few feet of pipe. These investigations indicated that none of the surface wells were safe and should not be used. Two driven wells examined were found satisfactory. Partly, as a result of this investigation, a bill was framed, authorizing the Board of County Commissioners to construct, maintain and operate a system of water supply and distribution. This bill, unfortunately, was vetoed by the governor. Other wells have been examined in Lucas County.

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## A FORMULA FOR FINDING THE AREA OF A CIRCULAR SEGMENT.

Contributed by L. G. Hall.

While on a piece of preliminary survey work for an irrigation project some time ago, the writer found it necessary to compute in a comparatively short time the areas of a large number of circular segments of varying radii and rises. His handbook together with a large part of the equipment had been lost in fording a stream, so he set to work with a slide rule and a pad and pencil to devise a simple formula for the purpose. The following formula was the result:

$$A = D^2 \left[\frac{R}{D}\right]^x$$

Where "D" is the diameter of the circle.

"A" is the area of the reqiured segment.

"R" is the rise of the segment. (All in the same units.)

"x" is a variable exponent whose values are tabulated below.

When R/D approximates 0.0 "x" equals 1.414
When R/D approximates 0.05 "x" equals 1.41
When R/D approximates 0.1 "x" equals 1.39
When R/D approximates 0.2 "x" equals 1.36
When R/D approximates 0.3 "x" equals 1.345
When R/D approximates 0.35 "x" equals 1.34
When R/D approximates 0.4 "x" equals 1.34
When R/D approximates 0.45 "x" equals 1.34
When R/D approximates 0.5 "x" equals 1.35

As is evident, this formula holds good for segments less than a semicircle only. For segments greater than a semicircle, the smaller segment must be computed and subtracted from the area of the circle.

While only approximate, this formula will be found to give results with errors in most cases much less than 1 per cent, which is well within the degree of accuracy of hydraulic coefficients, and will serve for practical purposes in many other kinds of work. Where great accuracy is required, value of "x" may be interpolated between those given in the table. The formula has the advantage that it does away with the tiresome process of figuring the subtended angle, taking the area of the sector, and subtracting that of the triangle. While many men have a prejudice against fractional exponents, handling them is very simple, depending only on the rule that the log of the power is equal to the log of the original number times the exponent of the power. The writer has frequently solved cases with this formula in less than a minute of time with no aid other than an ordinary slide rule. He believes that it will be a useful addition to the notebook of an engineer.

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The annual receipts of Philadelphia, Pa., from water rents are in excess of $5,000,000, in addition to free service rendered other municipal or charitable activities of a value at present rates of about $500,000. Operation and maintenance costs are about $2,000,000 per year. Interest and sinking fund charges on outstanding bonds chargeable to the Water Bureau amount to about $2,000,000 annually.

## CONSTRUCTION OF CONCRETE RESERVOIRS WITHOUT THE USE OF FORMS.

A concrete reservoir constructed without the use of forms was completed recently at Elmhurst, Ill. The reservoir was built by means of a cement gun by a method developed by the Dewey Cement Gun Co. of Chicago and Harry L. Emerson, Consulting Engineer, Chicago. The accompanying illustrations show various stages of the werk.

A light structural steel frame of angles and bars, with the required amount of spiraled reinforcing bars, with hooked ends securely fastened to the frame was erected. Over this reinforcement was placed a heavy triangular wire mesh. This serves as an additional reinforcement, but its chief purpose is to hold the concrete in place while setting. When the entire frame, reinforcing and wire had been erected heavy canvas ducking was stretched over the outside of the frame, and upon this, from the interior, about $1\frac{1}{2}$ in. to 2 in. of one part cement to three parts clean coarse sand and fine gravel were applied by cement gun.

Construction Views of Elmhurst, Ill., Reservoir: Fig. 1—Concreting Bottom. Fig. 2—Steel Frame. Fig. 3—Frame Covered With Canvas. Fig. 4—Building Up Wall. Fig. 5—Completed Reservoir.

When this coating had set a short time the canvas was removed and additional layers of dense concrete were applied from the exterior and the interior and in this manner the walls were built up to the desired thickness. The roof and cover were constructed in the same manner. On reservoirs about 20 ft. x 30 ft. the walls are made 6 in. in thickness and roof 3 in.

The first reservoir of this type was constructed at Cary, Ill., in 1912.

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## EXPEDIENT FOR LESSENING VELOCITY OF FLOW IN STEEP GRADE SEWERS.

An interesting expedient was adopted to lessen the velocity of flow in steep grade sewers now under construction at Copperhill, Tenn. The grades are as steep as 24 per cent. Where the excavation was practically all rock, the expense of breaking the sewer into short sections, with drop-manholes, was so great that the consulting engineer, Mr. Walter G. Kirkpatrick, adopted the expedient of laying the joints of pipe zigzag in the grade plane. In laying the pipe, the first hub is turned as far to the right as practicable, and yet get tight joint; the next joint is turned similarly to the left, and the next to the right, and so on, giving the pipe a slightly zigzag course, which is expected to check the velocity of flow.

## RESULTS OF A PITOMETER SURVEY.

The results of a pitometer survey at Auburn, N. Y., are described as follows by J. Walter Ackerman, Chief Engineer and Superintendent of Water Works, in the last annual report of the Water Board.

On May 25, 1915, the Board accepted a proposal for a pitometer survey of the distribution system of the city, and a test for slip of the pumps. The survey was contracted for the sum of $3,000, with a guarantee to save sufficient water to pay for this amount, based on a cost of 3 ct. per 1,000 gal., extending over a period of one year; and it also included a check of the register of the large meters in the system. This contract indicated that not less than 274,000 gal. of leakage daily would be found and stopped. A comparison of the pumping data from March 7 to July 11 (the date when the first leaks were stopped), showed an average Sunday pumping record of 6,228,000 gal., while on Sunday, Sept. 25, it amounted to only 5,410,000 gal., a saving at that time of over 800,000 gal. daily, or three times the amount of the guarantee. Another method of testing the saving was a comparison of pumpage during the night shift from 12 o'clock midnight, to 8 a. m., Sunday. The average pumpage on this shift from March 7 to July 11 was 1,857,000 gal.; and on Sept. 25 this pumpage amounted to only 1,452,000 gal., a reduction for eight hours of 407,000 gal. This amount for the entire 24 hours would represent a saving of 1,221,000 gal. Subsequent records taken during the year 1915 show this computation to be well authenticated. The total expense of this survey, including installation of the 31 corporation cock gaging points with permanent cast iron street boxes, and such other connections as were necessary for testing meters, pumps and transmission lines, etc., together with the house to house inspections and examinations and repairs to leaks, etc., amounted to $4,370.

The test for slippage on the 10,000,000-gal. R. D. Wood pump (in service since 1902) was shown to be 4.22 per cent; for the Holley Gaskell, equipped with Hill valves, the slippage was shown to be 5.56 per cent. and the 10,000,000 Snow pump at the Upper Station, installed in 1895, showed an average slip of 5.76 per cent. The transmission main between the two stations, 8,725 ft. in length, showed a discrepancy of only 1.13 per cent, but this was negative.

## TRAVELING WATER SCREEN.

Most industrial plants draw their water supply from lakes or rivers which are more or less contaminated with debris and refuse. Pumps and condensers are naturally sensitive to these materials, and as a consequence various methods have been developed for eliminating this kind of trouble. An effective arrangement for removing the solid matter from pumped water is shown in the accompanying illustration.

This is known as the Chain Belt traveling water screen. Essentially, it consists of a screening surface which may be either bars or racks or wire cloth. This screening surface is so mounted that it travels upward and out of the water. In order that this operation may be continuous the screening surface is made endless so that as it passes up and out of the water it turns over wheels and descends into the water back of its ascending path. A clearer idea of the operation of this screening surface may be gained by referring to the photograph of the single unit shown as Fig. 2. The underlying idea of these screens is exceedingly simple. Their practical application, however, represents a period of development both as to their mechanical design and proper application extending over a period of several years.

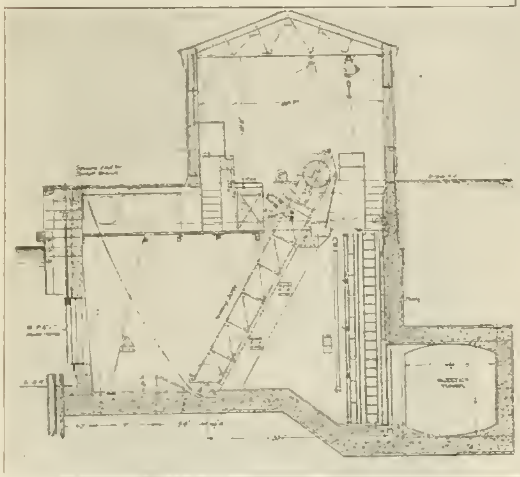

Fig. 1 — Transverse Section Through Screen House of the Northwest Station of the Commonwealth Edison Co., Chicago.

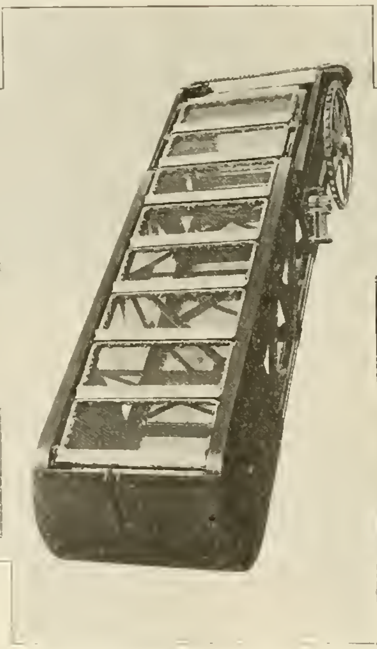

Fig. 2—Single Unit of Screen.

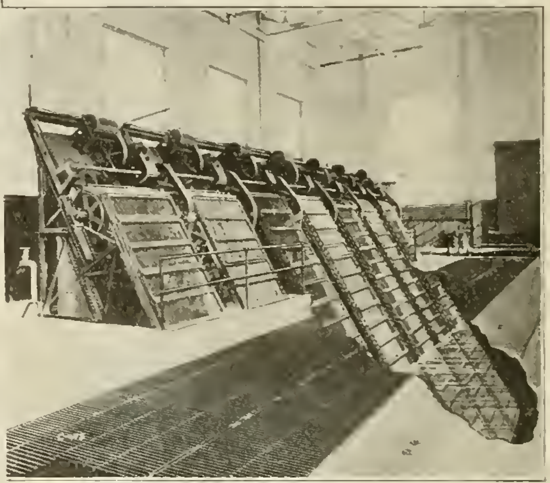

Fig. 3—Cutaway View of Chain Belt Travelling Water Screens at Delray Plant of Edison Illuminating Co., Detroit, Mich.

Actual installations of this machine are shown in the illustrations. Fig. 1 shows the installation at the Northwest Station of the Commonwealth Edison Co., Chicago, Ill. The screen shown in Fig. 2 was installed at the plant of Morgan & Wright at Detroit, Mich. Fig. 3 is a cutaway view of seven traveling screens installed at the Delray plant of the Edison Illuminating Co., Detroit, Mich. Several machines likewise have been located in plants along the Ohio, Mississippi and Missouri rivers where the variation in water levels is exceedingly great. These traveling screens also are used in connection with municipal water supplies. This screen is manufactured by the Chain Belt Co., Milwaukee, Wis.

## SEWAGE DISPOSAL METHODS OF 16 CITIES.

During May and June of this year Mr. T. D. Allin, Commissioner of Public Works and R. V. Orbison, City Engineer, of Pasadena, Cal., made an inspection trip to the sewage disposal plants in various cities. The investigation was made for the cities of Pasadena, South Pasadena and Alhambra, which are contemplating the installation of a joint disposal system. In a report issued recently Messrs. Orbison and Allin summarize the methods employed by a number of the cities visited by them.

Atlanta, Ga.—The topography of Atlanta is such that it was necessary to construct three disposal plants to handle their sewage. The first plant visited was the Entrenchment Creek Plant, located about six miles southeast from the City Hall. This plant was completed June 6, 1914, and was designed for a population of 50,000. It receives the trade wastes from the cotton manufactories which are cottolene, oils and dyes. Entrenchment Creek flows about 4½ miles to South River, and during dry weather flow the dilution with the effluent from the disposal plant is 1 to 2. (Attendants, one foreman, two day laborers and one night watchman.)

Proctor Creek disposal plant, the second one inspected, was placed in operation on Aug. 8, 1912, and designed for a population of 30,000. It is situated on Proctor Creek, a distance of four miles northwest from the City Hall. The trade wastes handled by this plant are iron, gas manufacturing wastes and calcium oxide from the Prestolite Gas Co. Proctor Creek flows about five miles from plant to the Chattahoochee River, and its dry weather flow dilution with the disposal plant is about 1 to 1. This plant also takes care of the night soil from 30,000 people, making the sewage very strong. (Attendants, one foreman, one day laborer and one night watchman.)

Peachtree Creek Disposal Plant, the third and last one we visited, is situated on Peachtree Creek, about five miles northerly from the City Hall, and was designed for a population of 80,000. It was constructed Sept. 8, 1913, and is identical with the other two plants, consisting of Imhoff tanks, sprinkling filters and sludge beds. The effluent discharging into Peachtree Creek has a dilution during dry weather of 1 to 5, and from this point the Creek flows about five miles to the Chattahoochee River. It handles practically no trade wastes, only iron from the iron works, which has stained the filter material an iron color. This plant receives 8,000,000 gal. of sewage daily through the Imhoff tanks, but only one-half passes over the sprinkling filters. The attendants at this plant are one chemist, one assistant chemist, three day laborers and one night watchman. All of the control work of the three plants is done at the laboratory located at this plant, where Mr. Chas. C. Hommon, the chemist, is located. His home is only a few yards from the plant. All of the disposal plants are working fine and are not creating any nuisances.

Baltimore, Md.—Baltimore's disposal plant consists of Imhoff, hydrolytic and sludge digesting tanks, screens, sprinkling filters, secondary tanks and sludge beds. This plant is treating about 35,000,000 gal. of sewage daily. A portion of this plant was placed in operation during 1911. This did not include any Imhoff tanks. In August, 1915, 28 circular Imhoff tanks, radial flow, were placed in operation. (One of these tanks was converted into an aerating tank with a continuous flow and continuous aeration.) After the effluent leaves the tanks it passes through cylindrical screens 12 ft. diameter by 11 ft. length, using monel metal screens 24-in. mesh. These screens are made at the plant and are more durable and cheaper than those originally purchased. Thirty acres of sprinkling filters are in use, using 6,000 Merritt and Taylor square nozzles spaced 15 ft. by 15 ft. The beds range in depth from 8 ft. at upper end to 9 ft. at lower end. After the sprinkling filter effluent has passed through the secondary tanks, it is passed through a power house, developing 200 K. W. Later on they expect to develop 200 hp. It is estimated that 1,785 lb. of sludge at 60 per cent moisture is obtained from every cubic yard of wet sludge. This sludge has been contracted for at 81 ct. per ton of 10 per cent moisture, the city delivering the sludge to a drying house erected at the plant by a company which reduces the moisture content from 60 to 10 per cent at their own expense. The city owns 450 acres at the disposal plant, situated on the west bank of the Black River, about six miles southeast from the City Hall.

The Imhoff tanks were not working in a satisfactory manner, in fact part of them were not in operation, due to their bad condition, probably caused by overloading before having been developed to their maximum capacities. The sprinkling filters were giving fine results and no nuisance. At the sewage pumping station the screenings from coarse bar screen amount to 6 cu. ft. per 1,000,000 gal. of sewage treated, at 50 per cent moisture, using a press manufactured by the Coffin Mfg. Co. of Boston. The city is about 50 per cent sewered.

**Philadelphia, Pa.**—Most of the sewage of Philadelphia is being discharged into the water courses. The remainder is treated at the disposal works located on Pennypack Creek, a short distance from its entrance into the Delaware River. This disposal plant, built in 1912, was designed for a population of 10,000, although only serving a population of 5,000, treating about 1,250,000 gal. of sewage daily. The plant consists of screens, grit chamber, Imhoff tanks, sprinkling filters, secondary tank and sludge bed. The final effluent is given a hypochlorite treatment for further purification, 15 lb. of lime per 24 hours is used to correct the acid in the sewage. The sprinkling filter bed contains one acre of 5 units—6 ft. in depth of 1 to 3 in. trap rock. Taylor square nozzles spaced 10.8 ft. are used. The sewage is fresh when it reaches the disposal plant and the results of the plant are highly satisfactory. The grounds around the plant are being improved.

**Plainfield, N. J.**—Plainfield, with a population of 20,000, is at present constructing a modern purification plant, consisting of Imhoff tanks, sprinkling filters, secondary tanks and sludge beds. The Imhoff tanks are designed for a population of 40,000, or 4,000,000 gal. daily flow. One and three-quarter acres of sprinkling filter beds 6 ft. deep will treat the Imhoff effluent. The former method of handling the sewage was through screens, septic tanks, contact beds and sludge beds. This method was not satisfactory and the new plant was designed and is now being constructed to remedy this.

**Fitchburg, Mass.**—Fitchburg, with a population of 44,000, has an average daily flow of 3,500,000 gal. and a dry weather flow of about 2,500,000 gal. This city has a modern and successfully operated plant, consisting of grit chambers, rectangular Imhoff tanks, dosing tanks and two acres of sprinkling filter beds in one enclosure, with 16 separate feeding pipes so arranged as to cut out about 8-ft. portions of the beds at a time. This bed is 10 ft. deep with the lateral distributors near the surface, using the Worcester nozzle. Following the sprinkling filter beds are secondary Imhoff tanks, circular with a radial flow. The sludge from the secondary tanks is pumped back to the preliminary Imhoff tanks, while the preliminary tank sludge is lifted into the drying beds just above the tanks. The dosing tanks are two in number with a capacity of 45,000 gal. each operated by siphons under a head of from 8 to 3 ft., 5½-minute discharge and with a 3,000,000-gal. flow has a cycle of 36 minutes. Fitchburg has a combined system with a grit chamber in town. It costs about $2 per cubic yard to clean this chamber. The time between the center of the city and the effluent from the secondary tanks is between 6 and 7 hours. Dilution into stream is about 2 to 1, except in summer, when the creek is practically dry. The city owns 120 acres, but is not using all of it at present. The sludge is used for filling in low ground and does not bring a revenue. The grounds are being beautified by planting grass, ornamental shade trees and flowers. The attendants consist of a chemist, assistant chemist and three laborers.

**Brockton, Mass.**—This city has a population of 63,000, is about 85 per cent sewered and has an average daily sewage flow of 2,250,000 gal. with a separate system. Trade wastes are from the tanneries and shoe factories. The sewage is run through coarse screens and then through a Wiend screen and then pumped about three miles to the purification works, consisting of sprinkling filters, secondary tank and sand filters. The cost of operation at the pumping plant and screens is $30,000 a year, and at the disposal works $10,000 per year. The screenings from the Wiend screen are collected in bags and are de-watered by the centrifugal process, requiring about four minutes. The screenings amount to 5,000 lb. daily. The sewage is septic when it reaches the pumps. These pumps have been in service for 22 years. Sprinkling filter beds one-half acre, average depth 6½ ft., underdrained with half tile, distributing laterals spaced 14 ft., and risers 12½ ft. staggered, using Merritt and Taylor nozzles. Sewage applied at the rate of 900,000 gal. per day. Sprinkling filter bed operated with butterfly valves. Plain secondary tank, dimensions 100 ft. by 50 ft., 4½ ft. deep.

There is in operation at the purification works, an activated sludge testing tank which Prof. Robert Spur Weston of Boston is experimenting with as a clarifier only. This tank is 10x10 ft. by 8 ft. deep, using 16 12x12-in. filtros plates. Air is used at the rate of 1.8 cu. ft. per gallon of sewage treated minimum to 2.25 cu. ft. maximum, with 25 per cent sludge. Results from the tests are highly satisfactory.

**Worcester, Mass.**—Population 170,000, with a combined system. The average daily flow is about 100 gal. per capita. The city disposes of its sewage by chemical precipitation, septic tanks and 72.6 acres of sand filters. The sludge is pressed and hauled out to a dump where farmers haul away all they want. The balance is used for filling in low ground. Owing to the growth of Worcester and the increased cost of sand filters, this city will have to adopt other methods for the purification of its sewage, and with this in view experiments have been made with Imhoff tanks and sprinkling filters, and it is their intention to try out the activated sludge process in the near future.

**Rochester, N. Y.**—In 1915 there was constructed and placed in operation a disposal plant to handle the sewage from the Brighton District. This plant consists of screen and grit chambers, Imhoff tanks, sprinkling filters, secondary tanks and sludge beds. Before the screened sewage enters the Imhoff tanks, it is passed through Pelton wheels (with a head of 69 ft.) and is capable of developing 6 hp. for each sec. ft. of sewage. Each wheel is belted to a 10 k. w. d. c. generator, and the resultant power is used to light the plant and run the cranes.

The Imhoff tanks have a sludge capacity of 1.84 cu. ft. per capita for four months. The screens and grit chambers are designed for a population of 25,000 and the balance of the plant for 10,000. The average daily flow of domestic sewage is estimated at 100 gal. per capita, with an infiltration as high as 300 gal. per capita daily.

Rochester is now constructing a disposal works consisting of grit chambers, Riensch Wurl screens, Imhoff tanks and sludge beds, which will serve that portion of the city not included in the Brighton District. This plant is designed for a population of 430,000 and will have a capacity of 55,500,000 gal. daily with a combined system. The effluent will be discharged into Lake Ontario.

**Batavia, N. Y.**—This city has a population of 13,000 and an average daily flow of sewage of 2,000,000 gal. The plant consists of Imhoff tanks, sprinkling filter and sludge beds. The filter area is one-quarter of an acre, and is being dosed at the rate of 8,000,000 gal. per acre. The results are highly satisfactory, even though the filter bed is overloaded.

The sludge has been used to fill in the low land around the plant and the superintendent's home (which is only 40 ft. from the sludge beds), and the superintendent stated that neither he nor his family, consisting of wife and four healthy children, have ever been bothered with odors from the plant.

**Cleveland, O.**—Cleveland's sewage at present is simply screened and the effluent discharged into Lake Erie. They have, however, an activated sludge testing plant designed to handle 750,000 gal. of sewage daily. This plant complete cost about $15,000 and is of sufficient size to enable them to work out their problems on a large scale.

**Canton, O.**—This city has a population of 60,000, and is entirely sewered. They have a combined system with a daily flow of 2,500,000 to 5,500,000 gal., with a maximum of 6,000,000 gal. The sewage flows 6 or 7 miles through a segment block sewer to the purification works, consisting of coarse bar screens, grit chamber, Imhoff tanks, contact beds and sludge beds. The Imhoff tanks are rectangular, two in number, and each tank has three units of three compartments designed for a future population of 120,000. The contact beds contain 7.23 acres, 6 ft. in depth, using crushed slag and washed gravel for the filter material. The sludge beds are in two units of three sections each, one unit being covered with a glass house to facilitate the drying of sludge during rainy weather. The disposal works cost $260,000 and the outfall sewer cost $200,000.

**Columbus, O.**—In 1908, Columbus constructed a disposal plant consisting of screens, septic tanks, sprinkling filters and final settling basins. This plant was designed for a population of 200,000 and a daily dry weather flow of 20,000,000 gal. Today, with a population of about 225,000, they are remodeling the septic tanks into Imhoff tanks and adding sludge beds. Ten acres of sprinkling filter beds are now in use.

**Mount Vernon, O.**—Population, 10,000. The sewage from this city is passed through coarse bar screens, then through Imhoff tanks and the effluent turned into Owl Creek without further treatment. Dilution in the creek at extreme low water is about 1 to 20. The Imhoff tanks are rectangular, 30x80x27 ft. deep. The sludge bed has a capacity of 562.5 sq. ft. per 1,000 inhabitants. The disposal works are about one mile from the business center, and Gambier St., which is now being paved with brick is within $1\frac{1}{4}$ mile of the plant.

**Chicago, Ill.**—The sanitary district of Chicago is experimenting with activated sludge on the packing-house sewage, and they are getting very satisfactory results, although the quantity of air that is being used per gallon of sewage treated is rather high when compared with that of other cities. On the other hand, the stockyard sewage is more difficult to handle than any other sewage known, unless it be sewage containing tannery wastes. The fill and draw method was started in January with 20 per cent sludge, and shortly afterwards changed to the continuous flow process, using from 5 to 6 cu. ft. of air per gallon of sewage treated. This tank has a capacity between 30,000 and 100,000 gal. daily. Armour & Co. are operating an activated sludge testing plant. The results obtained are very gratifying and it is very probable that this process will be used to purify all of their sewage.

**Milwaukee, Wis.**—After conducting numerous experiments, Milwaukee has constructed and put into operation an activated sludge plant designed to handle 2,000,000 gal. of sewage daily. At present they are only treating 1,200,000 gal. per day, using 25 per cent activated sludge, four hours' aeration, a settling period of about 40 minutes and 0.25 cu. ft. of air per minute per square foot of tank surface, or 1.77 cu. ft. of air per gallon of sewage treated with the air at 4 lb. pressure. This gave an effluent containing no suspended solids, stable after 5 days and a bacteria reduction of over 98 per cent. The remarkable features of Milwaukee's plant are the total absence of odors and the high degree of purification at a reasonable cost.

**Mason City, Iowa.**—This city has a population of 20,000 and a daily average sewage flow of 600,000 gal., or 30 gal. per capita per day. The purification plant designed and under construction to handle the sewage consists of Imhoff tanks, sprinkling filters, secondary tanks and sludge beds. This plant is designed for 1,000,000 gal. sewage daily. The Imhoff and secondary tanks are rectangular. The filter bed contains one acre, 8 ft. deep, using the Taylor square nozzle spaced 11 ft. Both the tanks and filter bed are roofed with steel roofing, using pebble dash finish with white Madusa cement. Sludge bed capacity is 270 sq. ft. per 1,000 inhabitants. The total cost of the plant will be $140,000, or in terms of the present population, $7,000 per 1,000 inhabitants.

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## THE MILL CREEK IMPROVEMENT PROJECT, ERIE, PA.

Bids will be opened next week for the construction of the largest flood prevention project that has come up for letting this year. The work calls for the building of a 2-mile reinforced concrete tube for carrying the waters of Mill Creek through the city of Erie, Pa. This tube will extend from Presque Isle Bay to the city limits and for the greater portion of its length will follow the present channel of the creek. At various sections, however, the new location leaves the old creek channel in order to secure better alignment.

The tube will be 22 ft. horizontal diameter and 18 ft. vertical diameter and will be constructed by the cut and fill method. It will be of uniform internal dimensions from the outlet to the inlet, about 12,000 ft., except for street transition sections at the ends. It will be laid on a grade ranging from 1 per cent to 1.4 per cent and will rest for its entire length on rock foundation. A cross section of this tube is shown in Fig. 1.

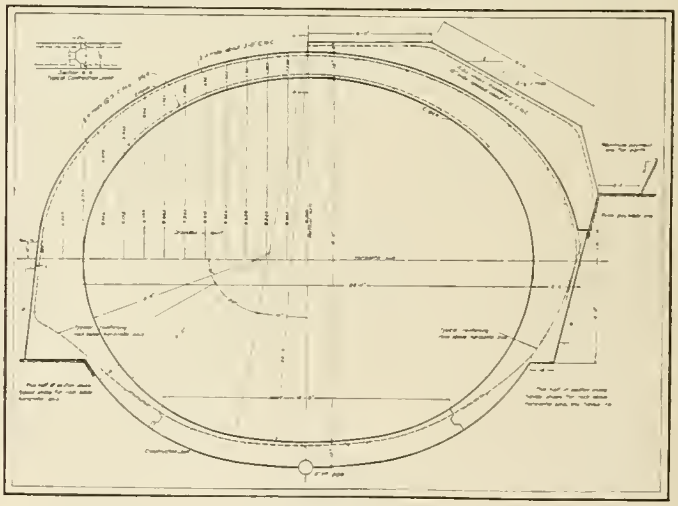


Fig. 1—Typical Section of Tube.

The intake will be about 1,000 ft. in length and will consist of diverging sloping retaining walls and earthen embankments. Fig. 2 shows a cross section. The outlet will be about 400 ft. in length and will consist of diverging ashlar and rubble retaining walls. Both the inlet and the outlet will have concrete floors for a portion of their length.

The estimated quantities for the principal items are as follows:

| | |
|---|---|
| Earth excavation, cu. yd. | 106,700 |
| Rock excavation, cu. yd. | 128,000 |
| Concrete, cu. yd. | 56,550 |
| Reinforcing steel, tons | 800 |
| Portland cement, bbl. | 85,000 |

In addition the work requires the underpinning of 18 buildings along the location of the tube and the excavation of several thousand cubic yards of concrete masonry and stone and brick masonry from retaining walls and culverts along the line of the work.

The concrete in the tube will be a 1:2:4 mix and will be placed in two operations. The invert covering, a width of about 14 ft. in the bottom, will be placed first in alternate blocks without employing top forms. The surface will be screeded with a template, rolled with a steel roller, floated and troweled smooth. The second operation will be the placing of all that portion of the tube above the invert, for which metal forms must be used. There will be no longitudinal joints in the tube above the invert. Contraction joints will be required at intervals of between 30 ft. and 75 ft.

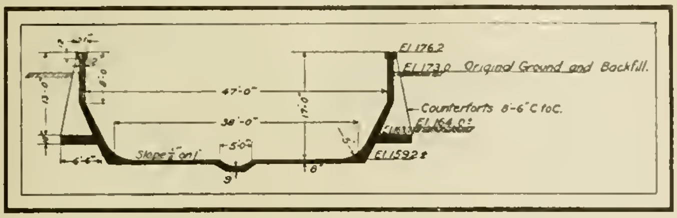


Fig. 2—Cross Section of Intake.

Ribs will be placed across the top of the tube at all street crossings and at other places where special loads may come upon the tube. It is the intention to place webb walls under building walls, etc., for permanently carrying the load from such structures. These ribs or webb walls in general will be not less than 1 ft. thick. They wall, in general, will be not less than 1 ft. thick. They concrete up as high as 12 in. above the outside of the tube.

The face walls, coping and buttresses of the reinforced concrete retaining walls will be composed of a 1:2½:5 concrete. This proportion will be used for the concrete for the side lining of the intake. On this portion of the work the concrete will be placed directly against the rock, which will act as a back form. The footings of the reinforced concrete retaining walls, and of the floor at the intake and outlet will be a 1:2½:5 mix. The concrete in the wing walls at the outlet also will be a 1:2½:5 mix, but may contain "plums" not exceeding by volume 40 per cent of the total volume of the wall.

The contract provides that the work must be completed within 22 months and that by May 1, 1917 400 lin. ft. of concrete must have been placed. The rate of progress thereafter must be at least 800 lin. ft. per month.

Bids for the Mill Creek improvement project will be opened Dec. 19 at the City Hall, Erie, Pa. Farley Gannett is the Consulting Engineer and F. G. Lynch is the City Engineer.

## COST OF FILTER PLANT OPERATION AT CINCINNATI, O.

The total cost of operating the filter plant of Cincinnati, O., during 1915, was $4.05 per 1,000,000 gal. of filtered water delivered in to the service, according to the report of J. W. Ellms, Superintendent of Filtration in the last annual report of Water Works Department.

There was expended for the two coagulating chemicals, sulphate of iron and caustic lime, the sum of $25,426.67, or $1.43 per 1,000,000 gal. of filtered water delivered into the service. For disinfection with liquid chlorine, the sum of $1,498.49 was expended, or $0.984 per 1,000,000 gal. of filtered water delivered into the filtered water reservoir.

The increased cost of operation and maintenance was due to the uniformly greater turbidity of the water treated, to unusual maintenance charges on account of the repair of the roofs of the head and chemical houses, and to the reconstruction of the filter beds. The increased cost for coagulating chemicals over the figure for 1914, amounted to $0.22 per 1,000,000 gal. of filtered water delivered into the service. The cost of repairs on the roofs was $0.07 per 1,000,000 gal., and for reconstructing the filter beds, $0.34 per 1,000,000 gal. These three items constitute 94 per cent of the increased cost for operation and maintenance over the cost figures for 1914. The increased consumption of filtered water is also a cause for the advance in the cost figures.

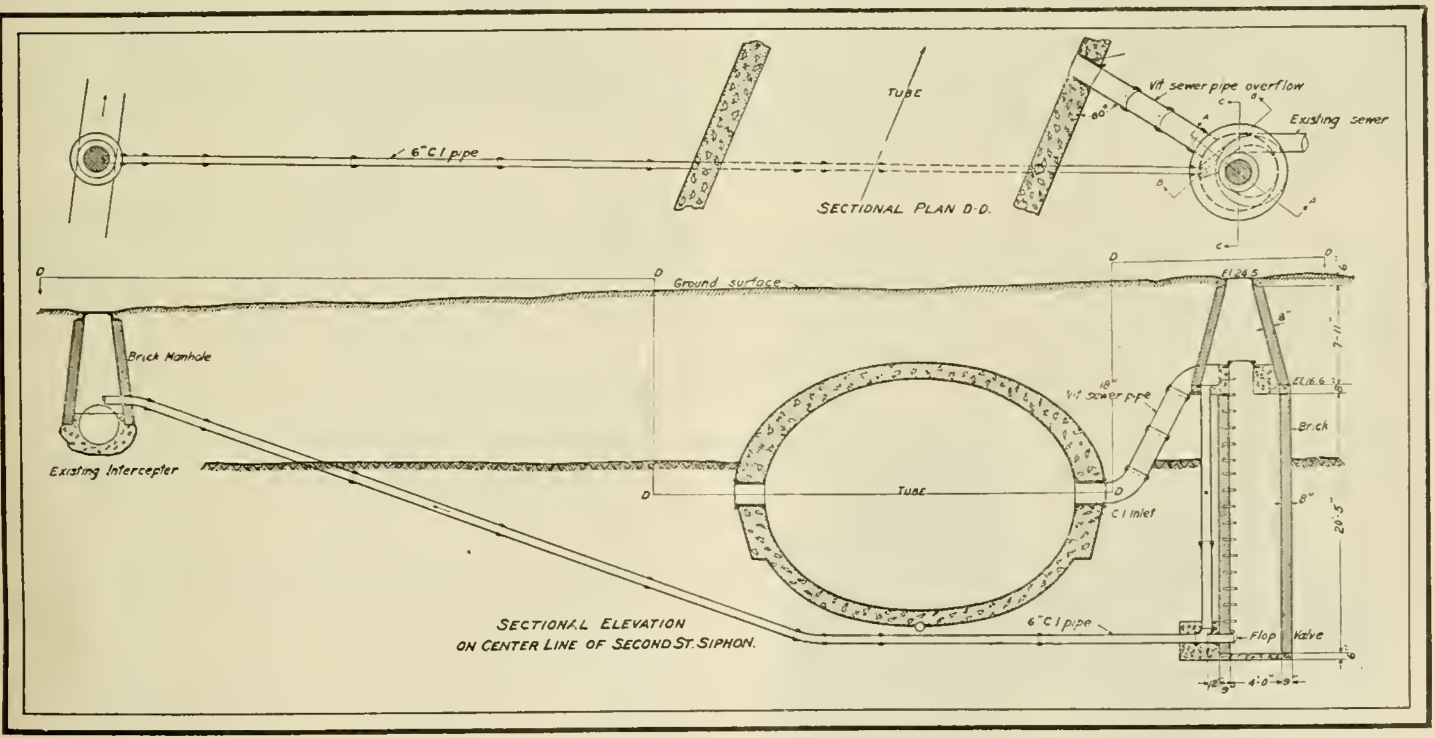


Fig. 3—Method of Siphoning Existing Sewers Under the Tube.

The following table gives a summary of the operation and maintenance unit costs on the basis of the volume of filtered water delivered into the service. The cost of coagulating chemicals is also given, but is, of course, to be understood as included in the total costs named, and not as an addition to them.

Cost per 1,000,000 gal. of filtered water delivered into the service:

| | 1908. | 1909. | 1910. | 1911. | 1912. | 1913. | 1914. | 1915. | Av. for 8-year period. |
|---|---|---|---|---|---|---|---|---|---|
| Operation ... | $4.19 | $4.17 | $3.91 | $3.77 | $3.46 | $3.44 | $2.99 | $3.29 | $3.65 |
| Maintenance .. | .05 | .09 | .28 | .35 | .38 | .48 | .39 | .76 | .35 |
| Total ....... | $4.24 | $4.26 | $4.19 | $4.12 | $3.84 | $3.92 | $3.38 | $4.05 | $4.00 |
| Coagulating chemicals ... | $1.72 | $1.89 | $1.93 | $1.86 | $1.78 | $1.67 | $1.21 | $1.43 | $1.69 |

TABLE I.

| Month. | Water treated, 1,000,000 gal. | Total water filtered, 1,000,000 gal. | Filtered water used for washing filters, 1,000,000 gal. | Water used, wasted and lost by leakage, 1,000,000 gal. | Filtered water delivered for consumption, 1,000,000 gal. |
|---|---|---|---|---|---|
| January | 1,513 | 1,507 | 24 | 7 | 1,481 |
| February | 1,357 | 1,353 | 28 | 5 | 1,324 |
| March | 1,454 | 1,449 | 26 | 6 | 1,422 |
| April | 1,494 | 1,467 | 22 | 27 | 1,444 |
| May | 1,443 | 1,439 | 22 | 5 | 1,416 |
| June | 1,558 | 1,556 | 12 | 3 | 1,542 |
| July | 1,643 | 1,640 | 16 | 3 | 1,622 |
| August | 1,605 | 1,597 | 38 | 8 | 1,557 |
| September | 1,568 | 1,563 | 33 | 5 | 1,528 |
| October | 1,640 | 1,613 | 37 | 28 | 1,574 |
| November | 1,478 | 1,472 | 32 | 7 | 1,438 |
| December | 1,493 | 1,490 | 21 | 3 | 1,468 |
| Totals | 18,252 | 18,150 | 317 | 113 | 17,822 |

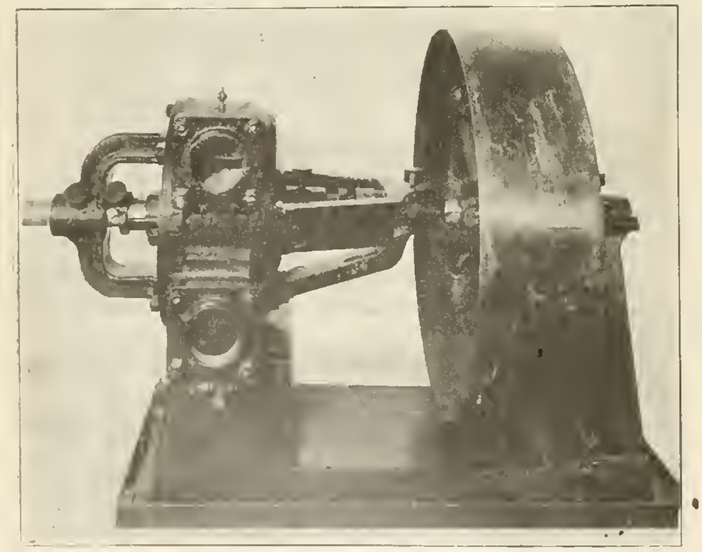
TABLE II.

| Month. | Total number of filtering hours. | Average period of service (hours). | Total number of filter washings. | Average length of time required to wash a filter (min.). | Per cent of total water used for washing filters. |
|---|---|---|---|---|---|
| January | 8,957.57 | 16.69 | 542 | 3.73 | 1.63 |
| February | 8,037.95 | 15.62 | 498 | 3.64 | 2.08 |
| March | 8,588.33 | 18.48 | 466 | 3.55 | 1.81 |
| April | 8,741.33 | 21.04 | 398 | 3.84 | 1.52 |
| May | 8,609.99 | 23.45 | 362 | 4.19 | 1.55 |
| June | 9,416.38 | 44.01 | 219 | 4.34 | .81 |
| July | 10,013.54 | 41.27 | 247 | 4.77 | 1.02 |
| August | 9,668.80 | 15.58 | 626 | 4.48 | 2.44 |
| September | 9,457.00 | 19.46 | 515 | 4.50 | 2.15 |
| October | 9,704.92 | 17.70 | 582 | 4.50 | 2.33 |
| November | 8,954.51 | 17.13 | 538 | 4.50 | 2.23 |
| December | 8,934.26 | 25.18 | 352 | 4.50 | 1.42 |
| Totals | 109,084.58 | ..... | 5,345 | .... | .... |
| Averages | ........ | 22.94 | ..... | 4.21 | 1.75 |

Table I gives the quantities of water in gallons for each month which have been treated, filtered, used, wasted and lost by leakage, and the amount of water delivered by the filtration plant for consumption. Table II shows the total number of filtering hours for each month, the average period of service of the filters, the number and length of washings and the average percentage of filtered water used for washing.

## A SELF-PRIMING ROTARY PUMP.

A rotary pump that is coming into considerable use in connection with water supplies for domestic purposes and for irrigation is illustrated herewith. The points of interest in this pump are its simplicity, positive action, high efficiency and constancy of efficiency under a long range of heads and speeds. The pump is self-priming, has only two moving parts, and is positive in its action. It is claimed that it will develop approximately 65 per cent efficiency under ordinary installations.



The Viking Rotary Pump.

A pump similar to the one shown in the illustration is now in operation in the water works station of Ames, Ia. The Ames installation has a capacity of 1,000 gal. per minute and is belt driven by a 15 HP. motor. It pumps against a head of 105.5 ft. and requires 0.55 K. W. per hour. The attention required does not average more than 15 minutes per day, as the operator simply investigates as to whether the pump is operating properly, tends to the lubrication and sees that the packing glands are not leaking, etc. The pump described above is known as the Viking. It is manufactured by the Schirmer-Frensdorf Co., Cleveland, O.

## PERSONALS.

Henry Welles Durham, county engineer of Bergen County, Hackensack, N. J., who has been absent on leave with his regiment, the 7th New York Infantry, at McAllen, Tex., has returned to his office, having come back to New York with his command, which has been mustered out of active duty with the United States Government.

At the annual meeting of the Calgary Branch, Canadian Society of Civil Engineers, Dec. 2, A. Scott Dawson, M. Can. Soc. C. E., M. Am. Soc. C. E., chief engineer department of natural resources, Canadian Pacific Railway Co., was elected chairman for the ensuing year, and Sam G. Porter, M. Can. Soc. C. E., M. Am. Soc. C. E., assistant chief engineer, Irrigation Branch, Department of the Interior of Canada, was re-elected secretary-treasurer.

Albert A. Lane, contracting engineer, has removed his office from Youngstown, O., to 324 Union building, Cleveland, O., which is a more central location for his operations. He will continue to specialize in factory buildings and industrial plants of reinforced concrete and steel construction. Among the work which he has designed and built during the past few years are included four buildings for the General Fireproofing Co. at Youngstown, the Standard Oil distributing plant at Youngstown, the National Tire & Rubber Plant at East Palestine, O., the Standard Oil Co. plant at Akron, O., and buildings for the McGraw Tire & Rubber Co. at East Palestine, O.

Raymond W. Parlin of 265 Ocean avenue, Brooklyn, N. Y., has been appointed Deputy Commissioner of the Department of Street Cleaning of New York City. Mr. Parlin specialized as a student in the Massachusetts Institute of Technology in sanitary engineering and has had an exceptionally broad experience in municipal work, including street cleaning. He has been connected with the Massachusetts State Board of Health as assistant engineer; with W. S. Johnson, consulting hydraulic and sanitary engineer of Boston, as assistant engineer and construction superintendent; in general contracting business; with the Washington County Water Co. of Hagerstown, Md., as engineer; with the American Waterworks & Guarantee Co. of Pittsburgh as a member of the operating department for plants in the northern division, and as acting superintendent at Clinton, Iowa; with the Clarion River Power Co. as assistant chief engineer; with S. M. Gray, consulting engineer, Providence, R. I., as engineer in charge of preliminary surveys for the new Providence water supply, and for the past three years he has been a member of the staff of the New York Bureau of Municipal Research, where he has specialized on street cleaning and refuse disposal. He has been engaged in special studies of the conditions in Greenwich, Conn.; New Bedford, Mass.; Rochester, N. Y.; Buffalo, N. Y.; New York City; Norfolk, Va., and Detroit, Mich.

## OBITUARY.

Frederick C. Fisher, 5127 Indiana avenue, Chicago, president of the Ferro Construction Co., died last week at the Washington Park Hospital following an operation for appendicitis. Mr. Fisher was born at Lake Linden, Mich., 45 years ago and was a graduate of engineering of the University of Michigan. He was engineer in charge of the construction of the railroad bridge at Thebes, Ill. He erected what was then known as the largest grain elevator in the world at West Superior, Wis., over a decade ago.

## INDUSTRIAL NOTES.

The Lidgerwood Manufacturing Co., New York, has opened a branch office in the Hibernian building, Los Angeles, Cal. Charles A. Baechtold will be in charge of this office.

Ike S. Byrum, special representative of the Troy Wagon Works Co., Troy, O., has completed arrangements for the handling of Troy motor truck trailers by O'Rourke-Muller Motor Co., 853 Carondelet street, New Orleans, La. The above concern has stocked a complete line of Troy trailers.

The National Tube Co., Pittsburgh, Pa., has had motion picture films made illustrating the manufacture of National pipe from ore to finished products. Exhibitions of these films were given before the Wilkes-Barre District Mining Institute at Wilkes-Barre, Pa., on Dec. 9, and before the National Association of Stationary Engineers, at Copley, Pa., on Dec. 12. The series also will be shown before the American Society of Marine Draftsmen, Newport News Branch, Newport News, Va., on Dec. 15.

The Purington Paving Brick Co. of Galesburg, Ill., has become a licensee of The Dunn Wire-Cut Lug Brick Co. of Conneaut, O., and will engage extensively in the manufacture of wire-cut lug brick. The Purington company is one of the biggest paving brick concerns in the United States, with a daily output capacity of about 350,000 brick. The Purington organization consists of F. G. Matteson, president and treasurer; George C. Prussing, vice-president; C. D. B. Howell, vice-president; W. H. Terwilliger, secretary, and W. G. D. Orr, general manager.

J. A. & W. Bird & Co., of Boston, Mass., distributors of Ripolin enamel paint, have arranged to have George Price, who has been manager of the New York office, 120 Broadway, handling the metropolitan district for the past eight years, and who recently completed a trip through the south, engineer and handle the sales department covering the entire territory south of New York as far as Mississippi and also including the states of Louisiana and Texas. The selling policy, it is understood, will remain practically the same, with, however, a larger number of distributors.

The annual sales convention of the Blaw Steel Construction Co. was held on Friday and Saturday, Nov. 17 and 18, at Pittsburgh. As last year proved by far to be the most prosperous in the company's history, and indications point already that next year will greatly exceed it, great enthusiasm was evident at all times. Friday morning was devoted to a tour of the plant. Mr. McArthur, chief engineer, Mr. Rawley, general superintendent, and Mr. Loxterman, manager of the service department, spoke briefly on new appliances and new methods in concrete form construction worked out during the past year. The new Blaw bucket was the topic in the afternoon as well as on Saturday forenoon. The many advantages of the Blaw bucket were brought home in very telling fashion by Mr. McWhirk, who is in charge of the bucket department. As has been the custom in the past, the convention ended with a banquet at the Concordia Club. Over sixty men were present.

Excavation and Railways Issue
of

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
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Fourth Wednesday Each Month.....Buildings and Structural......$1 Yearly
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Any Two or More Monthly Issues, 75 Cents Each Per Year

Volume XLVI. CHICAGO, ILL., DECEMBER 20, 1916. Number 25.

## WHY DO RAILWAYS LOSE THEIR RATE CASES?

With few exceptions, the rate decisions of the Interstate Commerce Commission have been fundamentally against the railway companies. For this result it is the habit of railway officials to damn the Commission. A poor card player blames his luck, but it seems not to have occurred to railway officials that there is more than a distant kinship between them and the consistent loser at cards.

The writer has studied the decisions of the I. C. C. for many years, has appeared before the Commission as a witness, and is acquainted with members of its technical staff. He is satisfied, in spite of all the imprecations that have been hurled against the judgment and fairness of the Commission, that the reason why railway companies have been so uniformly unfortunate in the outcome of their rate cases is not to be explained away by casting aspersions as to the fairness or levelheadedness of the Commission. The evidence presented by the railways has been insufficient to convince the Commission that rates should be raised to the extent desired by railway companies.

Let any railway president divest himself of prejudice to as great a degree as possible and study the evidence in any rate case that his company has lost. Let him cease temporarily to be guided by the opinions of his attorneys and himself look the evidence in the face. If he can assume a judicial attitude he will see a state of things that will jar his faith both in the railway method of presenting the testimony and in the character of the testimony itself. If he is discerning, his first generalization from such a study will be this:

**A rate case before a Commission should be treated after the manner of the presentation of facts to a board of directors, and not after the manner of a legal contest.**

Lawyers, trained in court experience, are rarely capable of assuming anything but a fighting attitude, yet such an attitude before a Commission is almost fatal to the cause of the client. Not only does it arouse antagonism, but it creates suspicion to a degree that is evidently not comprehended by those who have never served on Commissions or on the technical staffs of Commissions. Too frequently the suspicion is justified, for the tendency of most attorneys is to conceal every fact that may be at all damaging to a contention, even to the extent of curbing a witness who, uncurbed, would tell the whole truth.

The writer appeared before a public service commission not long ago in an appraisal and rate case in which he acted as engineer for a utility company. The attorney for the company assumed the usual belligerent attitude and also sought to cut off the writer's testimony where it was unfavorable to the company. At the end of the first day's hearing the Commission requested the company to withdraw its attorney from the case and permit its engineer not only to present his testimony, but to examine other witnesses. The company acceded to this unusual request, and the rest of the hearing proceeded without further wrangling, a man to man talk, over a table. There was a frankness and completeness of testimony such as is rarely seen in any case.

It is not here contended that attorneys should thus be eliminated from rate cases, but what is illustrated by this case is the desirability of selecting attorneys who themselves will assume a proper attitude and will work with the engineers to give all the facts to the Commission regardless of consequences. Candid differences of opinion will arise, but a Commission is far more likely to give credence to the testimony of a witness in behalf of a company if there is evident desire to conceal nothing.

The second generalization that a discerning reviewer of testimony in a railway rate case will make, is this:

**A witness who is permanently employed by a company feels so strong an allegiance to the company that, in spite of himself, his testimony is biased.**

Of course, there is a natural bias on a Commission's part in favor of its own witnesses, but this bias is accentuated by knowledge that a permanent employee of a company usually feels that he has more to gain through the winning of a rate case than has an employee of a Commission. Even where a company employs outside experts to assist in presenting facts, there is bias against them in the minds of commissioners, but the bias is less pronounced and may become slight if the outside expert shows perfect frankness, coupled with complete knowledge of the facts. It is noteworthy that public utilities other than railways are more and more coming to depend upon outside engineers to appraise their properties and present testimony in rate cases. Is there not much significance in the fact that such utility companies have frequently secured marked increases in rates and have seldom suffered large cuts in rates, unless the cuts were fully warranted?

How many railway presidents have paid even slight attention to the methods of handling rate cases by electric light, gas, traction, water and telephone companies? Most utility companies have not felt the self-sufficiency that characterizes railway companies. Being small, most utilities have usually not had a sufficiently large engineering staff to handle an appraisal and at the same time to take care of their customary work. But this weakness has become their strength. Forced to rely upon the help of outside engineers, they have engaged men of recognized standing who could not be made parties to any concealment or distortion of facts.

Consulting engineers are, of course, not without human frailties that incline them to decide questions in favor of their clients, but it is noticeable that it is their theories rather than their statements of fact, that are most frequently attacked.

A third generalization that a student of railway rate cases will make, is this:

**There is usually a lack of coordination of all the testimony resulting in unexplained inconsistencies, as well as gaps that leave an impression of doubt.**

Here again railway presidents might do well to study some of the utility company cases. Often in preparing the evidence for a utility company case, the engineer employed by the company not only has charge of the appraisal, but of the study of the accounting records, both as to capital account and operating expenses. In addition, he selects the real estate and right-of-way experts and directs their work. Finally—and this is of supreme importance—he makes a careful, analytical study of each class of rates. In brief, the engineer coordinates the entire case. To do so, he must of course understand accounting and be able to direct the accountants. Where the book value differs from the appraised value, he seeks the reasons for the difference and does not rest until every reason ceases to be a mere generality, and is converted into dollars. Then he studies the operating expenses for many years past to establish, as far as may be, the ratio of maintenance and depreciation to investment in depreciable property. But, being more than an accountant, he goes beyond the accounts into the engineering records to ascertain what property has been abandoned without being charged to maintenance or depreciation accounts. He may thus discover inflation in "book values," but he accomplishes something that more than offsets such inflation by proving that the true operating expense has been greater than the accounting records indicate, and that, therefore, if the past is any criterion of the future as to obsolescence and inadequacy of plant, the company is entitled to earn depreciation annuities in excess of those normally provided.

Instead of making any such comprehensive historical accounting analysis, the railways have uniformly fought against it, and, in the writer's opinion, have lost many a case that otherwise would have been won. By contending that depreciation reserves are wholly unnecessary in railway operation, and that renewals should be met as a current maintenance expense, the railways have sought to save their surplus and by doing so, lost their entire rate cases. Seeking to bolster up their net earnings by this illogical procedure, they have brought themselves to the very precipice of ruin in many an instance, and have at times precipitated themselves over the precipice.

Of all the contentions by which railways have killed their cause, the absurd argument that a railway needs no depreciation reserves is perhaps the most astonishing. The degree of the absurd claim that a large diversified plant needs no depreciation fund is best appreciated by studying the practice of the most successful great utility company in the world—the American Telephone & Telegraph Co., commonly known as the Bell System. Instead of a policy of hand to mouth living, this great company has long insisted upon providing adequate depreciation reserves for every item of its plant. Now witness the result: While the railways of America are unable to sell their stocks to provide for betterments that would yield a good profit, the Bell System finds no trouble in continuing its amazing growth.

Of course, like the poor card player, railway companies attribute their own unfortunate condition entirely to the "bad deal" they have received, and point to the relative freedom of the telephone companies from Commission interference. And, also, like the poor card player, the railway companies will insist that one must have held their very hand of cards to appreciate its weakness. It is always the fashion to ascribe financial and other losses to ill fortune. In this respect, at least, the railways have garbed themselves in the latest, though also the oldest, mode.

Put plainly—and this is the time for plain speaking—the railway companies have botched nearly every great rate case thus far presented to the Interstate Commerce Commission. The fundamental cause is a smug, self-complacency that has led to ignorance of the methods of the utility companies that are succeeding under precisely the same conditions that yield the railways nothing but failure. Wrapped up in worship of their own precedents, imbued with the idea that to know anything about railway problems one must have always been a railway employee, railway officials have attained to the climax of financial absurdity in their belief that depreciation funds may be wise for others, but are useless to railways. The origin of this absurdity is not far to seek. It has sprung from the early practice of bonding railway property under mortgages that called for net earnings about double the bond interest. To make it appear that net earnings were double the bond interest, it was usually necessary not to deduct anything for a depreciation annuity. The deception once begun had to be continued, and it very soon was argued that there was no deception involved, for renewals could be met when they materialized. Yet when they did materialize on a large scale—as when extensive relocation of lines became necessary to handle traffic more economically—renewals were not entirely charged to maintenance. For the most part they were then charged to capital. This practice resulted in strong opposition to government appraisal of railway property, for fear that overcapitalization would be disclosed—an opposition that is not yet ended, in spite of accumulating evidence that the increments in right of way and land values have more than offset other reductions in book values that an appraisal might make necessary. So one wrong bred another and led to the greatest mistake of all—the damning of Commission regulation and Commission appraisal of railway property.

The writer feels that unless Commission regulation of railway rates is to fail completely, there must soon come a complete change, not only in the manner of presenting the railway side of these cases, but in the theory that underlies railway accounting and financing. The Interstate Commerce Commission itself has urged the necessity of providing depreciation reserves. Instead of seizing the suggestion as a life-saver, the railways have cast it away.

Summed up in one sentence, the writer's theory of the proper presentation of the most important single element in a railway rate case, is this:

**Welcome the I. C. C. proposal to establish adequate depreciation reserve funds, and then demand that rates be raised sufficiently to provide the reserves and still leave adequate net earnings upon the appraised value of the property.**

Every effort should be made to finish the railway appraisals speedily, even though the appraisals be admittedly incomplete. It will be said that the present refinements of appraisal work will admit neither of speed nor low cost. Shall appraisal definements be permitted to go to such extremes that railways are unable to meet the demands of the country, while engineers and accountants split the last hair? The writer himself has used the highest degree of appraisal refinement in certain cases and he has also used the most rough and ready methods. He knows that these two extremes of method yield far less difference than is to be had as a result of differences in appraisal theories. He has talked with many appraisers and finds them of the same mind. Hence, for all practical purposes, every railway in America, if it wishes, can prepare an appraisal within 18 months, that will serve the immediate purposes of a rate case.

Later refinements of appraisal work can then be carried out at leisure.

The immediate effect of establishing adequate depreciation funds will be to give greater confidence to investors in railway securities, for it will be realized that the era of hand to mouth maintenance of railway property has come to an end. To add to this feeling of security, the depreciation funds of each railway should be invested in the bonds of other railways, thus diversifying the locality investment and keeping the funds in a condition that permits of easy liquidation through the sale of the bonds.

## WHY ELECTRIFICATION OF RAILWAYS WILL MAKE WORK FOR RAILROAD CONTRACTORS.

The economic success of the electrification of several hundred miles of the Chicago, Milwaukee & Puget Sound Ry. through the Rockies, has probably been the deciding influence that has led the Great Northern Ry. to announce plans for electrifying all its lines in the state of Washington at a cost of about $20,000,000. Of course an other influence leading to such a decision has been the revival of railway business, resulting in substantial increases in net earnings.

Some railroad contractors may not realize that in electrifying these western railways a very large part of the money will be expended in building reservoirs, dams, ditches and pipe lines; for it is planned to develop water-power sufficient to generate all the electric current used to run the trains. The cost of the power plant equipment—waterwheels, generators, transformers, etc.—is a comparatively small part of the total cost. Hence, of an expenditure such as $20,000,000, a very large part will go to contractors who build the reservoirs, "flow lines," foundations and pole lines.

It seems wise to make this explanation, for we find that a good many railroad contractors are apt to regard the work of electrifying a railroad as being out of their field entirely, whereas the electrification involves much construction that they are competent to handle.

With millions of horsepower of water still undeveloped, and with the price of fuel steadily rising year after year, it has long been evident to farsighted engineers that practically all railways will eventually be operated by electricity. The word "eventually" seems now likely to become definite and to give place to say, "within the next 15 years."

The editor knows of several contracts between western railways and large hydro-electric power companies involving the purchase of large quantities of power at about half a cent per kilowatt hour, which is at the rate of about 5 ct. per horsepower per day of 8 hours. It is obvious that a considerable amount, say 30 per cent, of the power can be lost in transmission along the wires to the electric locomotive and still leave a very low cost for the power at such a rate as ½ ct. per k.w.h.

The advantages of electric traction do not end with the low cost of power. In fact it is claimed that the savings in locomotive maintenance are almost as great as the saving in power cost. The maintenance cost of locomotives, exclusive of round-house attendance, amounts to three-fourths the cost of the fuel that drives them. Annual repairs to locomotives average 18 per cent of their first cost, exclusive of renewals of locomotives that are scrapped, which is another 4 per cent of the first cost. Although electric locomotives have not yet been long enough in service to give a complete answer to the question of repairs on them, the known facts point to a maintenance cost about one-third that on steam locomotives. It should be remembered that a boiler on wheels, running at high speed over rails, is subject to tremendous wear and tear. Due to the necessary type of rather crude engine and boiler construction, a steam locomotive is an extravagant consumer of coal. Furthermore, a very considerable part of the rolling stock of a railway is now kept busy hauling fuel for its own locomotives.

When all the costs—not only operating expenses but interest and depreciation charges—incurred through the use of steam locomotives are summed up, it will be found that the steam locomotive is already "out of date" on most large railways.

## IS A GREAT REVIVAL OF RAILWAY BUILDING IN SIGHT?

Were it not for two things, one political and the other semi-political, we should be witnessing right now a great migration of capital into the railway field; for the growth of the country districts has not kept pace with the growth of the cities, and there is a very evident lack of transportation facilities. But capital, while keenly sensible of the need of more and better railways, is fearful of not being able to get its reward. State railroad commissions, particularly in the west and south, have hammered at railway rates for 10 years and still hammer. The Interstate Commerce Commission has limited powers and is so overloaded with work that the railway investor sees little assurance of getting both prompt and adequate regulation of rates from that source. Finally there has come the menace of labor troubles on a gigantic scale, with a dose of political soothing syrup that would gag a mule.

In spite of all clouds, there is a sun still shining behind them, and the sun is the economic necessity for more and better transportation facilities. The nation's railway clothes fit it "too soon"—and the pants are up to the knees and its childhood vaccination marks clearly visible through the skintight coat sleeve. Everything that is of the railroad is oppressingly restrictive, and something has got to bust. What seam will rip first, we don't know, but we are certain that a rent must start somewhere and soon.

At present the railways are trying to influence Congress to do away entirely with the state regulation of railway rates and to give the Interstate Commerce Commission sole jurisdiction. But the old state's rights theory blocks a considerable part of the roadway to such a change. Already some state railway commissioners are earnestly advising against being shorn of their own Samsonian locks. Nevertheless the movement toward a radical change in government regulation methods, if not in policies, is well under way, and there is strong probability that the present Congress will do something radical. Whatever is done will undoubtedly serve to restore confidence in railway securities as a safe investment. It needs restoration of confidence, and nothing else, to start a new and great railway construction period. As indicated in another editorial in this issue, electrification of existing steam railways is probably the most pressing change, if we except enlargements and changes in terminals and means of loading and unloading freight quickly.

The next step will be the building of new branch lines as feeders to existing trunk lines. This will open up some new territory, but that is of far less economic consequence than better development of territory now tributary to railways. Branch lines are too far apart in the majority of agricultural states. In some of the states, notably Texas, there are so few railways that most of the land remains almost worthless.

Railroads always have been, and in spite of the automobile, always will be, the greatest agents in effecting development of agricultural lands. For some peculiar reason, the public has let political cataracts grow over its eyes till it can scarcely see the real worth of railways as general developers of agriculture. The suffering resulting from high food prices, due to this partial blindness, seems now acute enough to lead to an operation that will bring permanent relief. Here's to the hope that Congress will wield the knife courageously and speedily.

## MANUFACTURERS OPPOSED TO AN EXCAVATING MACHINERY SHOW.

In our November Excavation and Railway Monthly issue, we suggested that it might be advisable to hold an annual exposition or show of machinery and equipment used in excavating earth and rock. We have received letters from 10 manufacturers commenting on our suggestion, and only one of them is favorable to the plan. Even that one fears that it would be very difficult to display heavy machinery in operation, and feels that if the machine were not at work the show would lose most of its educational value.

The majority of these manufacturers seem to regard three objections as being so great as to outweigh all advantages. First, the size and weight of many excavating machines are such as to cause considerable expense in transporting and assembling them. Second, the machines should be exhibited in operation, which requires considerable area, varying conditions and suitable weather. Third, a great enough number of prospective buyers would not be likely to attend the show.

Two of these manufacturers have had experience at shows in allied fields, and do not seem satisfied with the tangible results. This, however, is not a sufficiently strong objection in itself, for it is not the immediate sales that alone warrant holding any exhibition of machinery. Exhibitions of this kind are primarily educational in their effect, and therefore like other kinds of publicity that are aimed to give possible users of a product a better idea of its economic efficiency and field of application.

Whether enough interest could be aroused among contractors and engineers engaged in excavation to induce a large number to attend a show is, of course, problematical. We believe that this difficulty could be overcome by proper publicity methods, particularly if an excavation machinery show were held jointly with one or more shows of other classes of machinery. One of the manufacturers suggests that the annual road machinery show already embraces exhibits of some of excavating machinery and might be enlarged to include all types of such machinery.

It is our belief that an excavating machinery show is likely to be successful only if held at about the same time of some other show. Perhaps there should be only one large annual exposition of machinery, devices and materials used in civil engineering and contracting. Comment is made on this matter in another editorial.

## PROTECTING WATER PIPES FROM FREEZING ON CONSTRUCTION WORK.

At this time of year there is scarcely a contractor's camp in the North that is not the auditorium for a variegated assortment of oaths every morning.

"What's the matter, Jack?"

"Oh, —— —— to —— pipes is froze harder than the —— —— hinges of ——."

Yet there are usually two kinds of heat insulators in abundance at most construction camps—straw and manure. The latter is particularly effective in preventing freezing of water pipes, for in fermenting or rotting it gives off heat. Manure also is a good heat insulator, if kept comparatively dry.

All porous heat insulators, like sawdust, straw, manure, etc., should be protected from becoming saturated with water, for when saturated they cease to retard the passage of heat appreciably. So a water pipe insulated with straw, or the like, should be protected from rain. A wrapping of old canvass, preferably oiled, around the straw-clad pipe is an almost perfect protection.

Have you noticed that freezing of pipes buried in the ground, or otherwise insulated, usually occurs at a joint in the pipe? This is because the joint has been leaking and has saturated the surrounding earth, or other insulator, with water. Water itself is a fairly good transmitter of heat; hence if the insulating material becomes saturated by a leaking pipe joint, you may look for trouble there. This makes it exceedingly important to stop every leak in a pipe line during freezing weather.

Water in rapid motion will not freeze at 32 degrees—"the freezing point"—but will stay liquid at several degrees below that point. But, what is equally important, if the water is in motion in the pipes a new supply of warmer water is constantly arriving at any exposed place. It takes time for the water to lose its heat, and before there is time for the water along an exposed part of a pipe to freeze, a new supply of warmer water has arrived. This is the reason that valves or spigots are often left open to prevent freezing. This is also the reason why pipes are not so apt to freeze up in the day time when water is being drawn, as at night when no water is moving. It will often pay even to keep a pump working all night to prevent pipes from freezing.

It is rather curious, considering the simplicity and economy of the method, that provision is not more often made for draining pipes at night or whenever the water is not in motion. By a little care in laying the pipes so that they will drain toward a few drain valves that can be readily opened, all trouble with frozen pipes can often be avoided.

Often it is desirable to heat water well above the freezing point, so that it may stand in tanks, or pipes, for some time without freezing. This can be done either with live steam or with exhaust steam, led directly into a tank of cold water. The editor once had a camp cook who boiled all his vegetables in a barrel of water that was heated with steam from a nearby boiler. In that case exhaust steam was not used, for the cylinder oil in the steam would have flavored the vegetables too highly to suit the epicurean taste of the gentlemen of Italy who, although fond of oil, are not educated to the Standard Oil variety.

## THAWING FROZEN GROUND.

Frozen earth is as difficult to excavate as hardpan or shale, unless it can be undermined or thawed. Undermining is frequently impracticable and thawing, as usually done, is either very slow or quite expensive.

Where wood or brush is available at small cost, perhaps no cheaper way of quickly thawing ground is to be found than to build small bonfires over the surface and feed them continuously.

In trench digging small steam pipes may be laid along the line of the trench and kept supplied with steam from a small portable boiler. The pipes should be kept well covered with straw held in place with burlap or gunnysack. After the earth has thus been thawed to a depth of 6 or 8 ins., dig it out and relay the steam pipes in the trench and repeat the thawing process.

For post holes or short trenches quick lime is perhaps the most effective means of thawing. The lime is laid over the earth, wet with water and covered with straw. Fine charcoal spread over snow will "cut" its way down quite rapidly on a sunny day, even though the temperature of the air is very low. This is because anything black absorbs radiant heat and reflects none of it. Charcoal not only absorbs all the sun's heat, but conducts it fairly well, thus warming the snow beneath it till it melts. We have never heard of this principle being applied in thawing earth, but it seems worth the trial.

There is another principle that might be successful in thawing earth over small areas, such as post holes or short trenches, namely, the hot house principle. Cover the earth with a shallow wooden box, open at its lower end and cover with window glass at its upper end. The sun's rays penetrate the glass, but, upon striking the earth or other substance, the rays change their wave length and are unable to escape back through the glass with the rapidity that they entered. If the glass is double, with an air space between, a very small amount of heat that is trapped in this manner can escape.

Few people know the amount of heat that the sun delivers to the earth every day. When the sun's rays fall perpendicularly upon an area, enough heat is delivered in an hour over each square foot to melt nearly 2 lbs. of ice. Why, then, it may be asked, does not the sun melt snow very rapidly? Because the snow, being white, reflects nearly all the sun's rays.

## A SUGGESTED ANNUAL JOINT SHOW OF CIVIL ENGINEERING AND CONTRACTING EQUIPMENT AND MATERIALS.

Many manufacturers have expressed dissatisfaction with the results consequent upon exhibiting their products at annual shows. Some have ceased exhibiting and still more have never been induced to exhibit at all. Yet we believe that relatively few manufacturers doubt the effectiveness of exhibiting their products, provided a large number of interested men be gathered together to view them.

The problem, therefore, seems to be mainly one of attracting a big convention of engineers and contractors whose object is to study the products of manufacturers, and to do little else. Given the problem, how can it best be solved? By a series of shows of specialized products or by one large joint exhibition of the products of all manufacturers? There would appear to be but one answer. A series of shows in one city not only involves too much time, but it calls for an unprecedented speed in dismantling one show and installing its successor.

We have now two annual waterworks shows, two road shows, one cement show and one municipal show—all held at different places. Yet in many cases the very same men are interested in some of the exhibits in every one of these shows. There are several other shows of more or less civil engineering nature held annually.

It is obvious that a great deal of energy is being dissipated as a result of entire absence of coordination of all these annual expositions.

The latter part of January or early part of February is the ideal time for a show intended to interest the greatest number of contractors and engineers. The ideal place is the large city nearest the center of population, and that is Chicago.

The attractive power of a single large show of all the appliances, supplies and machines used by civil engineers and contractors would unquestionably be sufficient to draw several thousand men together every year. Every paper reaching these men would gladly assist in giving publicity to the great show. Manufacturers would be likely to secure orders during the show sufficient to recompense them for their immediate outlay, but of greater consequence would be the educational effect of their exhibits. The possible uses of labor-saving machinery and economic materials are vastly greater than the present uses. Actually seeing a display of this character, and listening to the word of mouth explanaticns, is admittedly effective.

As part of the great trek toward co-operative effort, will it not be wise to consolidate the many scattered shows cf a civil engineering nature into one great and supremely attractive annual exposition at the hub of the new America?

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## A HINT ON ECONOMIC MOTOR TRUCKING OVER VERY BAD ROADS.

Contractors often permit motor-truck drivers to operate at speeds of 10 to 20 miles an hour over very rough roads. The result is great wear and tear on the truck and its tires, also the truck is apt to be out of commission much of the time.

Wiser contractors have come to see that a better plan is to operate over bad roads at low speeds—5 to 10 miles an hour. If the road is exceedingly rough, a speed of 5 miles an hour is often the permissible limit. In that case it may be advisable to use a trailer with steel tires, the truck and the trailer hauling about 10 tons. Working two shifts about 80 miles can be covered per 24 hr. day, delivering a total of 40 tons, provided facilities for quick loading (or from bins) are available.

The Haskins Dolomite Co., of San Francisco, has been operating a 5-ton White truck with a Troy trailer in this manner. The distance from their dolomite quarry to the railway is 10.5 miles, and the truck makes four round trips every 24 hrs., working two shifts. The road is one of the worst of mountain roads, full of chuck holes, covered with dust often 6 ins. deep, with grades up to 10 per cent, one of which 10 per cent grades is 1.5 miles long. The truck requires 44 gals. of gasoline and 4 gals. of oil for the day's work of 84 miles. The daily operating expense is about $30, which is equivalent to 7 ct. per ton-mile, exclusive of interest and depreciation, but inclusive of tire renewals and current repairs.

In our November Excavation and Railway Monthly issue we published a letter from Mr. N. A. Eckart, of the San Francisco city engineering department, in support of the decision of that department that motor-trucking to the projected Hetch Hetchy dam would cost more than building and operating a temporary railway. We had questioned the wisdom of that decision, and had said that we believed motor-trucking could be done for less than the 15 ct. per ton-mile estimated cost of railroad haulage. We now submit the experience of the Haskins Dolomite Co., of San Francisco, in support of our statement that a motor-trucking cost of less than 15 ct. a ton-mile is not merely "the estimated cost of enthusiastic automobile salesmen," as Mr. Eckart puts it, but is based on well established experience.

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In the fiscal year 1916, 20 new water power projects which utilize national forest land began operation. This was an increase of 18½ per cent in the total number. In the fiscal year 1915 the number of new projects which began operation was 12. Forty-two per cent of the total developed water power of the United States utilize national forest land.

## SUB-DRAINAGE OF WET CUTS WITH VITRIFIED TILE ON MISSOURI PACIFIC SYSTEM.

During the period 1905-1911 extensive use of vitrified tile was made by the Missouri Pacific System for draining water pockets and wet cuts along its lines. In all 714 locations were worked. Of this total about 79 locations failed to give benefit, the reasons ascribed for the failure being (1) tile not placed at sufficient depth, and (2) tile not placed in proper location. In order to determine the value of the tile drainage for road bed an investigation was made of all the territory which had been worked previously. The results of this investigation are described by W. C. Curd, Drainage Engineer Missouri Pacific Ry. System, in the Bulletin of the American Railway Association, from which the following notes are taken:

In the conduct of the investigation locations were selected for examination where grade, soil, rainfall and others conditions were widely varied. At 70 locations the drains were uncovered at two or more points and examined for line, grade and signs of clogging. In the stretches of track inspected the drains varied from 100 to 3,000 ft. in length and were at depths of from 3 to 7 ft. below base of rail.

The investigation showed a remarkable benefit to have been derived through the strengthening of roadbed where drains had been properly installed and estimates made from most reliable information obtainable indicate a return of from 50 per cent to 200 per cent per year in the decreased cost of maintaining line and surface on the short pieces of track which were drained.

The failures reported were found to be due principally to improper installation, particularly with reference to depth of drain to the moving material in the roadbed. In these locations many of the drains were forced to the surface and completely filled. In those locations examined where proper methods of installation had been followed, the line and grade of tile was intact and entirely free of sediment or evidences of clogging.

The data gathered in the investigation dispels much of the doubt previously existing both as to the permanency of the drains and the benefit derived from them.

Mr. Curd does not believe it can be found that tile drains will produce a direct saving in dollars and cents in track maintenance, but the benefit would seem to lie in the development of more efficient track in locations where it was formerly found to be impossible to maintain good track. The benefit comes from the removal of slow orders and a more even distribution of the time of the section forces over their territory. In some cases it has resulted in an actual decrease of section forces, but this is an exception rather than a rule.

Conclusions drawn from the Missouri Pacific experience indicate if tiling be installed in accord with the following requirements, the greatest permanency and benefit will be assured:

Drains should be laid with bell end vitrified salt glazed sewer pipe of minimum diameter of 6 in. with unsealed joints.

The top of tile should be placed 1 ft. below frost line and a minimum distance of 1 ft. below unstable or moving material. Depth in each case should be carefully determined by test holes or inspecting excavation.

Tile should be laid to grade established by level and with all fall obtainable.

Location of center line of tile should be parallel to and from 4 ft. 6 in. to 7 ft. from center line of track.

Tile should be placed directly on bottom of trench. After it is laid to line and grade, and before backfilling, it should be covered with straw, grass or some such material to prevent loose particles in backfilling from entering the joints.

Trenches should be backfilled with cinders, with coarse material placed directly around and over the tile. Where walls of trench show signs of distortion from passing loads, sufficient quantity of riprap or coarse stone should be mixed with the cinders to brace the walls.

Pockets under track should be tapped with cinder-filled lateral trenches, and connected into tile drain trench, but without connection with tile drain except through the unsealed joints.

Remove all surface water from cuts by intercepting and side ditches, otherwise tile drain may be overtaxed and eventually fail entirely.

After drains have been installed it is essential to maintain free outlets to prevent backing water into tile.

The ends of drains should be surrounded and supported by concrete or dry masonry to guard against underwash.

To prevent small animals from entering tile, the outlet should be protected by rods or grating.

Failures of drains come from following causes:

Insufficient depth below moving material.

Shifting grade or alignment causing joints to open.

Insufficient grade to provide proper flow.

Location of drain in impervious material without providing adequate means for tapping saturated material with lateral drains or cross trenches.

Distortion of walls of trenches.

Tile drainage is not a panacea for all wet cuts and its use is not recommended without a complete knowledge of the conditions to be corrected. When these are known and proper methods of installation are applied much benefit is reasonably sure to follow.

## HANDLING SAND AND GRAVEL AT A COST OF 1.7 CT. PER CUBIC YARD.

A very interesting example of the economical handling of bulk material with a clam shell bucket is afforded by a recent dock installation at Buffalo, N. Y., for the Niagara Sand Corporation.

A wide-gage traveling derrick of the steam Whirley type was equipped with a 2¼-yd. wide, opening scraper type, Blaw clam shell bucket, as shown in accompanying photograph. This equipment handles sand and gravel which is previously pumped into the steam barge Pennsylvania, which has a rated capacity of 600 yds.

Sand and Gravel Unloading Outfit of the Niagara Sand Corporation.

Careful cost records, which have been kept, show that the average barge load is 620 yd. and the unloading time 4 hours and 10 minutes, or a gain in unloading time of 1 hour and 40 minutes over best previous unloading time.

The following analysis of the costs of this operation are based on original cost of derrick, average amount of material handled per 10-hour day 1,500 yd. and 250 days per year, making 375,000 yd. in all.

| | Per cu. yd. |
|---|---|
| Depreciation at 2 per cent ($200) | $0.00053 |
| Interest at 6 per cent ($600) | .00160 |
| Labor | .00866 |
| Maintenance | .00146 |
| Cost of fuel, oil, etc. | .00510 |
| | $0.01735 |

The clam shell which accomplished these results is the Blaw bucket, manufactured by the Blaw Steel Construction Co., Pittsburgh, Pa.

## MOTOR TRUCK FOR EXCAVATING, BACKFILLING AND TAMPING TRENCHES.

The San Diego Consolidated Gas & Electric Co. of San Diego, Cal., is using a motor truck for many of the operations in connection with the extension of its gas mains. On one recent 14,000-ft. installation of 2-in. pipe it was employed to excellent advantage in excavating the trenches, in backfilling them and in tamping them.

The 14,000 ft. extension offered an unusually difficult job of pipe laying. The line was over rolling ground and through a soil composed of adobe in which were a large number of small boulders and cobblestones. The work was done in July and the last rain had taken place early in March. On account of the dryness of the ground the digging was extremely hard.

Plow Attached to Motor Truck for Trench Excavation.

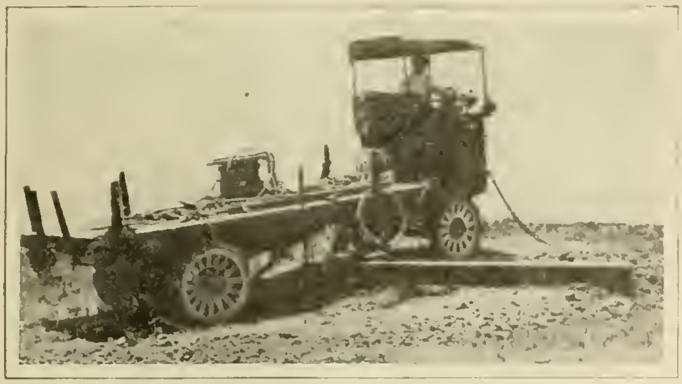
A single-point plow without a mole board was used in the trenching. This plow was attached to the motor truck underneath the axle in such a manner that the front end was held down by the weight of the truck. The depth of the cut was regulated by means of a shoe placed a short distance from the end of the plow. Four furrows were plowed. In the last two the beam of the plow was practically level with the ground, so there was nothing left to do but shovel out the dirt. On ordinary digging one man operated the plow and all he had to do was to loosen it up in case it was pulling too heavy on the truck.

The company has lately devised a plow having a double point and a mole board, which it is hoped will not only dig the trench but also will clear out the greater part of the earth. Experiments with this device have not been entirely successful as yet, but it is believed that within a short time an arrangement can be perfected whereby the desired results will be obtained. On one occasion when plowing in sandy loam the experimenters were able, by the use of the new plow and excavator propelled by the motor truck, to dig a 2 ft. trench and to remove from

Digging in Hard Ground.

it at least two-thirds of the dirt, the balance being handled by shovels.

The backfilling was accomplished by means of a filling board attached to the truck. This board had a steel shoe and was attached to the truck by a chain between the front of the truck and the outside of the shoe, by a chain from the first standard of the truck to the inside of the board, and by a pipe with a shoe on the end fastened to the truck so it had a vertical motion.



Method of Back Filling with Board Fastened to Truck.

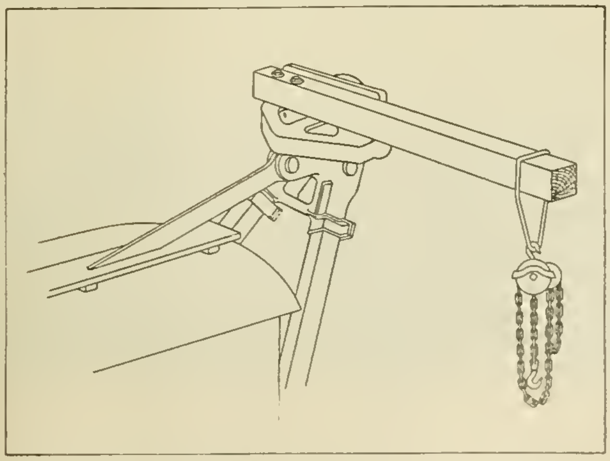
The shoe was for the purpose of keeping the filling board from digging into the ground underneath the truck.

The trench was tamped by driving the truck over it, a very satisfactory job resulting.

D. J. Young is Superintendent Gas Department of the San Diego Consolidated Gas & Electric Co.

## HANDLING HEAVY PIECES IN ERECTING STEAM SHOVEL.

A useful labor and time saving device for erecting a standard railroad type shovel is described by Mr. George W. Williams in a recent issue of the Excavating Engineer. The arrangement consists of a jib crane constructed, as shown in the accompanying sketch, by attaching a piece of 8x8-in. x 10-ft. timber to the A-frame collar, which will act as a center pintle, so that the timber can be swung around in any position. Attach chain falls or block and tackle at any convenient point on the timber jib and heavy parts such as jack arms, sheaves, chains, etc., can be handled with ease. Parts can be lifted from the idler car and placed in position alongside the shovel and jack arms put in place on the shovel without any trouble.



Jib Crane for Handling Jack Arms, Sheaves, Etc.

To get the timber up on the roof of the shovel and attach it to the A-frame collar is a comparatively simple matter. Fasten two ropes to the running board on the roof. Drop the bight of both lines to the ground and place the timber in them. Two men on the roof can easily roll it up. Swing the A-frame collar parallel to the shovel and place one end of the timber on it, supporting the other end on the roof of the shovel by blocking of the proper height. Bolt the timber securely to the collar and you will have a very simple and practical crane. A piece of T rail can be used if a timber is not available.

## A $100,000,000 RAPID TRANSIT DEVELOPMENT FOR CHICAGO.

An expenditure of about $100,000,000 during the next 9 years for improvements to the transit facilities of Chicago is recommended by the City Traction and Subway Commission. This initial 9-year construction program will, it is estimated, increase the present rapid transit facilities to 2½ times the present rush-hour schedule. It will provide for the construction of 11.1 single track miles of double track subway of which 6 miles are for rapid transit and 5.1 miles for surface cars; 64½ single track miles of elevated lines, 150 miles of new surface lines, and 111 miles of rehabilitated surface track. In order to provide a comprehensive system of rapid transit in 1950 an ultimate expenditue of $260,000,000 is proposed. This outlay, it is estimated, will build 53 miles of rapid transit subways, 5 miles of surface car subways, 158 miles of elevated roads and 525 miles of surface car line.

The initial construction program is divided in three-year periods and it is assumed that work can be started during the summer of 1917. In order to do this it will be necessary for a prompt acceptance of the plans by the city and the railroad companies and the obtaining of the necessary enabling legislation in time for a referendum vote at the election next April. The proposed 9-year construction program follows:

### First Three-Year Period, 1917-1920.

1. Commence immediately the construction of a two-track subway under State St., from a junction with the South Side Elevated at Eighteenth St., and running thence north to Chicago Ave., thence west to a junction with the Northwestern Elevated structure, $10,350,000.

2. Construct surface car subways under Washington St. and Jackson St. to Michigan Ave. or Grant Park, connecting with the existing West Side street car tunnels, $7,181,750.

3. Lengthen platforms on elevated stations, taking first the lines with the present heaviest traffic so as to obtain additional capacity at the earliest possible date, $1,306,400.

4. Construct immediately a two-track elevated extension south from Van Buren St. over Fifth Ave. and east over Polk and Eighth Sts., connecting with South Side Elevated, $810,060.

5. Extend the present stub terminal over N. Water St. east to State St. and south on State to the present loop station over Lake St., including a new river bridge on State St., $1,029,940.

6. Extend Market St. elevated line south from Madison St. to connect with the Fifth Ave. terminal of the Metropolitan Elevated, including additions to Fifth Ave. terminal, $658,030.

7. Add fourth track to South Side Elevated from the Eighteenth St. junction with the new subway to Forty-third St. and a third track extending from Forty-third St., including real estate for right of way, $3,926,100.

8. Add third and fourth tacks to Oak Park Elevated from Market St. to Paulina St., $1,361,600.

9. Add a third track on Metropolitan Elevated from Lake St. to Robey St. and rebuild Lake St. junction to form a physical connection and allow running of Logan and Humboldt trains over Lake St. east of this junction, $1,196,000.

10. Add a third track on Douglas Park branch from Marshfield Ave. station to Twentieth St., $678,500.

11. Allow for terminal transfers from surface to elevated lines in this period, $1,026,950.

12. Add a third track connection on Northwestern Elevated from Wilson Ave. to existing third track north of Argyle, $115,000.

13. Add a third track on Oak Park Elevated from Paulina St. to Campbell Ave. in order to complete an express track from Crawford Ave. to river, $290,950.

14. Add a third track on Garfield branch from Marshfield Ave. to Sacramento boulevard for express service to this point, $879,750.

15. Construct a new two-track line from Logan Square

to Irving Park Blvd., including new terminal yards at the latter point, $2,201,100.

16. Construct a new two-track line as an extension of the Humboldt Park branch to Grand Ave. with terminal yards, $871,700.

17. Construct a new two-track surface line connecting Oak Park and Garfield Park branches beyond their present western terminals, including storage yards in Forest Park, $701,500.

18. Construct a new two-track elevated structure on or parallel to Ashland Ave., from Twentieth St. on the Douglas Park branch to Sixty-ninth St. and Ashland Ave., including terminal yards, $5,944,350.

19. Construct a new two-track elevated connection between the new Ashland Ave. branch and the Englewood and the stockyards branches, $430,100.

20. Construct Marshfield Ave. junction to eliminate grade crossings and to allow of improved transfer facilities, $345,000.

21. Realign tracks and construct a new station at Division St. on Northwestern, $333,500.

Fifteen per cent for engineering, legal expenses, contingencies and interest during construction has been allowed in each of the above items.

22. Rolling stock required for additional rapid transit lines, including overhead, $9,497,000.

23. Surface lines requirements, additional tracks, rolling stock, etc., including overhead, $9,417,420.

Total estimated cost, first three-year period, $60,533,000.

The above estimate does not include the cost of powerhouses or substations for rapid transit lines, but does include substations for surface line, it being assumed that the corporation will continue to purchase all its power.

### Second Three-Year Period, 1921-1923.

1. Construct a surface car subway from Fourteenth St. and Indiana Ave. connected with the proposed Illinois Central station to and under Grant Park or Michigan Ave. to connect with the other surface car subways, $2,185,000.

2. Eliminate grade crossings on Fifth Ave. side of Union Loop and rearrange stations for new operation, $791,200.

3. Complete the realignment of the Northwestern tracks at Halsted St. and North Ave. to reduce the delays on account of heavy curvature, $632,500.

4. Add a third track to Ravenswood branch of the Northwestern Elevated and eliminate grade crossing at Clark St., $1,273,000.

5. Add a fourth track to the South Side Elevated from Forty-third St. to Sixty-third St., $1,124,700.

6. Add a fourth track to the Metropolitan Elevated from Lake St. to Robey St., $787,750.

7. Add a fourth track to the Metropolitan Elevated from Marshfield Ave. station to Twentieth St., $724,500.

8. Add a third track to Logan Square branch from Robey St. to Logan Square, $715,300.

9. Add a third track on the Oak Park Elevated from Crawford Ave. to Laramie Ave., $402,500.

10. Add a third track to the Garfield Park branch from Sacramento Blvd. to Laramie Ave., $1,002,800.

11. Add a third track to Douglas Park branch from Twentieth St. to Clifton Park station, $947,600.

12. Complete the connections between Oak Park and Garfield Park branches and storage yards, $448,500.

13. Construct the connection from Robey St. on the Logan Square branch to the Ravenswood branch at Roscoe St., $1,958,450.

14. Add a third track to the Metropolitan Elevated from Marshfield Ave. station to Lake St., $287,500.

Fifteen per cent for contingencies, engineering, legal expense and interest during construction have been included in each of the above items.

15. Rolling stock for rapid transit lines, including overhead, $3,217,000.

16. Surface line requirements, additional tracks, rolling stock, etc., including overhead, $8,018,000.

Total estimated cost, second three-year period, $24,516,300.

### Third Three-Year Period, 1924-1926.

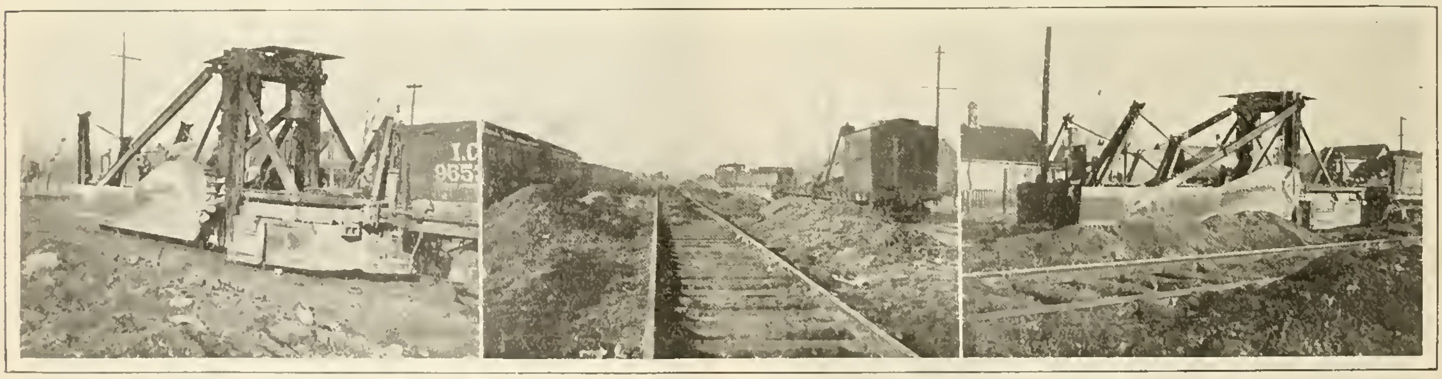
The expenditures in the third period are for additions to the rolling stock of both the rapid transit and surface lines and extensions of the surface lines, principally as feeders in the outlying districts to the rapid transit system developed in the first two periods. Estimated cost. including overheard, $11,302,000.

The grand total cash requirements for the above schedules of the three construction periods are $96,371,300.

The final report of the Commission, which consists of William Barclay Parsons, and Robert Ridgeway of New York, and Bion J. Arnold, of Chicago, will be submitted to the City Council some time this month. The figures given in this article are taken from a partial report made public early in December.

## MACHINE SPREADING IN TRACK ELEVATION WORK.

The Illinois Central R. R. at present has some very interesting track elevation operations under way between 96th St. and 120th St. in the city of Chicago. The work provides for the elevation of six tracks to a height of 14 to 16 ft. This particular portion of the general track elevation scheme of the railway involves the placing of some 700,000 cu. yd. of sand fill, requiring the use of 9,000 ft. of trestle over streets and 11,500 ft. of construction trestle.



Views of Spreader and Track Elevation Work of Illinois Central R. R. between 90th St. and 120th St., Chicago.

The filling material is obtained at Dune Park, Ind., and is hauled to the work in cars, and then plowed off the cars on the trestle. Each train consists of 30 cars, the capacity of the cars ranging from 36 to 38 cu. yd.

This material is spread by means of a Jordan spreader. Five to six train loads are dumped and spread by this means in a 10-hour day.

The force engaged on the track elevation work consists of 80 bridgemen and 200 track men. Two to three men are employed on the spreader.

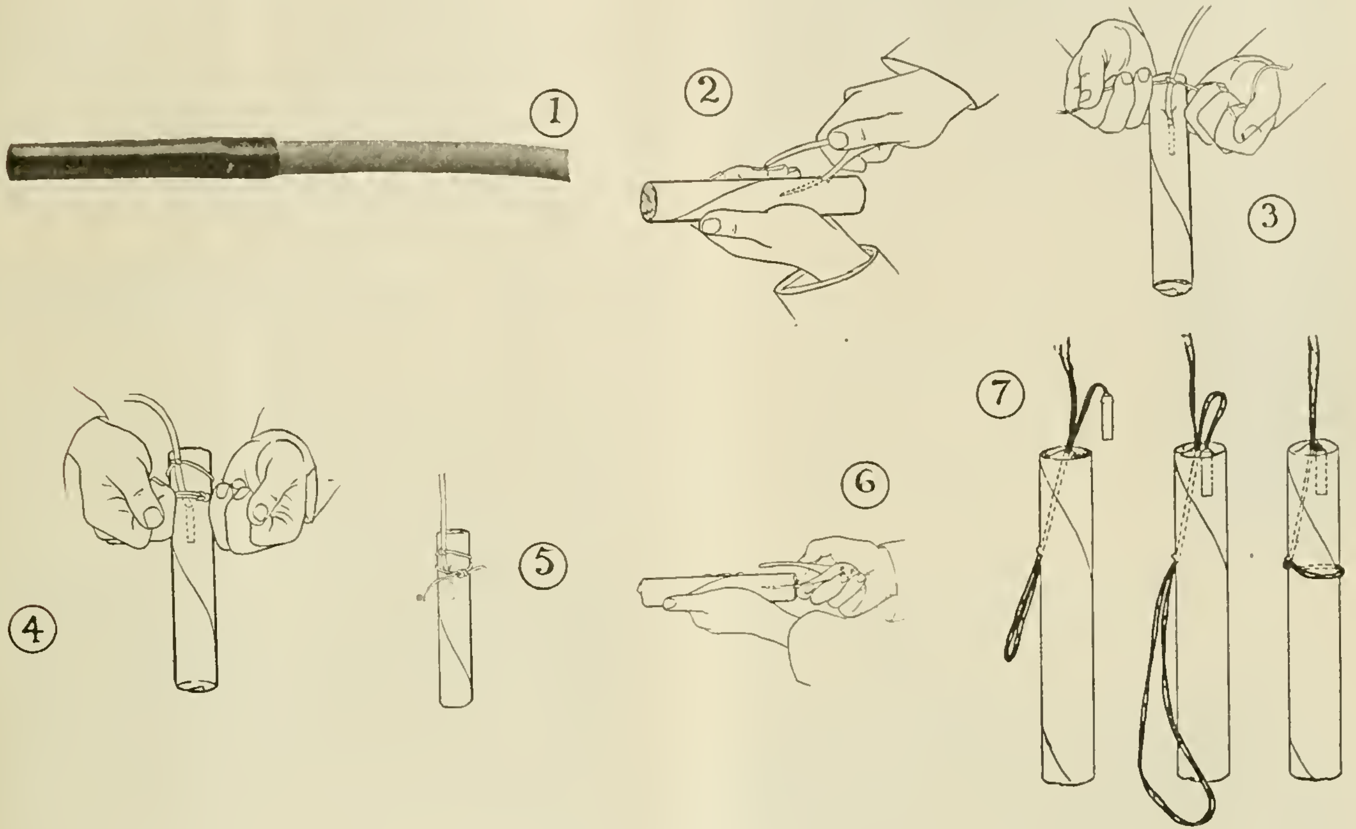
## THE PRIMING OF CHARGES AND FIRING OF BLASTS.

Contributed by Thomas M. Knight.

Explosives are divided into two classes—deflagrating and detonating. The deflagrating class require a spark or flame to explode or fire them, while the detonating ones are fired by means of a shock or concussion caused by an intermediate agent such as a blasting cap or electric blasting cap.

A good example of a low or deflagrating explosive is blasting powder, while dynamites, gelatine, and permissibles are the principal high or detonating ones.

The deflagrating explosives are generally exploded by the spark from a fuse, electric squib, or flame from the primer of some high explosive. Of these methods, the one employing the electric squib is probably the most satisfactory. These electric squibs are small pasteboard cylinders containing an ignition charge, with two wires attached to one end and a cork in the other to keep out the moisture. The cork is removed before firing. They are fired with an electric blasting machine, and in firing a small flame spits out which ignites the powder charge. The same principle is true when firing a powder charge by means of a fuse — the flame or spark fires the powder. While the fuse method is used quite extensively, it is not so satisfactory as the electric squib. With the electric squib the exact time of the explosion is at the will of the blaster (as it must be fired with a blasting machine) and it is not fired until everything is ready and everyone at a safe distance, while with the fuse method of ignition the time of explosion is uncertain, and there is more or less chance of misfires with their attending dangers. With the electric squib a misfire is practically impossible.



Figs. 1-7—Methods of Preparing Cartridges for Blasting.

In firing with the fuse, one end is placed in the powder cartridge and the other comes out or up through the bore hole. In making a blasting powder primer with an electric squib a paper bag or shell is half filled with powder, the squib is inserted, the bag is then filled with powder, and the neck securely tied. Where several bags or paper shells of powder are used, this primer is placed in the center of them. In this manner the explosion starts from the center and the force of it is expended in all directions, while in the case of firing with a fuse, especially if the charge of powder be a long one, the explosion starts at one end and works towards the other, thereby reducing the force of the explosion.

In exploding a charge of blasting powder with the primer of some high explosive, the primer is inserted in the center of charge of powder, as in the case of the electric squib, and is fired electrically. The flame caused by the explosion of the primer fires the charge. This is a very satisfactory method of firing and one that is employed exclusively when firing low powder or railroad powder.

In firing the high or detonating explosives the primary intermediate agent is the blasting cap. This blasting cap is a small copper tube containing a powerful detonating substance. The substance is exploded by a spark and the spark brought to it either by fuse or electrically.

In firing high explosives the detonating agent must be of sufficient strength to quickly and completely detonate the explosive. If the concussion caused by the detonator is insufficient, less force is developed by the explosives and naturally a greater quantity must be used. Then again, when high explosives are insufficiently detonated, poisonous gases are thrown off which are very sickening in open work and oftentimes fatal when inhaled in close work. The cost of the strongest grades of detonators is so trifling in comparison with the cost of explosives, that it pays to use only the best and strongest to insure the maximum results.

In priming a cartridge of dynamite with blasting cap and fuse, the fuse is first cut to the desired length. Care is taken to see that the cut is square and clean to enable the fuse to go into the blasting cap as far as possible. The fuse is then pressed gently into the blasting cap and crimped on (see Fig. 1) with a pair of cap crimpers. This fastens the blasting cap and fuse together firmly. Other methods of crimping, such as with the teeth or a knife, are absolutely condemned. They not only do a poor job, but are extremely dangerous as well.

The blasting cap and fuse is then inserted in the cartridge of dynamite. This is best done by one of two methods—inserting the blasting cap in the side of cartridge or in the end. When using the first method a diagonal hole, pointing downward, is punched in the cartridge with the handle of the cap crimper (see Fig. 2), and of sufficient depth to contain the entire blasting cap. The blasting cap should be as straight up and down as possible, as the greatest effect of the detonator is straight away from its loaded end and in a line with its longest axis. A string is then tied around the fuse (Fig. 3) and the operation is completed by tying the string around the cartridge (Fig. 4). Fig. 5 shows a completed primer ready to load.

In the other method the paper on the end of the cartridge is folded back and a hole of sufficient depth and diameter to accomodate the blasting cap is punched in the end of the cartridge (Fig. 6). The blasting cap and fuse is then inserted and the paper on top of end of the cartridge firmly pressed back. A cord is then tied around the cartridge and fuse and the cartridge is ready to fire. This method has the advantage over the other one insomuch that the blasting cap is pointed directly down into the charge.

The electric blasting cap is the same as the ordinary blasting cap except that it is closed at both ends and the detonating charge is fired electrically instead of by a fuse.

When priming with an electric blasting cap either of the two methods just mentioned may be employed. There is, however, a quicker way which is a favorite one with many blasters when using electric blasting caps. A slanting hole is first punched from the center of the end of the cartridge so that it will come out two or three inches down on the side. The electric wires attached to the electric blasting cap are doubled over and the looped wires shoved through this hole. These wires are then looped around the cartridge (Fig. 7) and another hole is made in the end of the cartridge a little to one side of the first hole and straight down. In this second hole the electric blasting cap is inserted and the slack taken up in the wires, then drawn fairly tight. This gives a primer where the electric blasting cap itself is pointed downward in the cartridge and where the wires do not cross at any place.

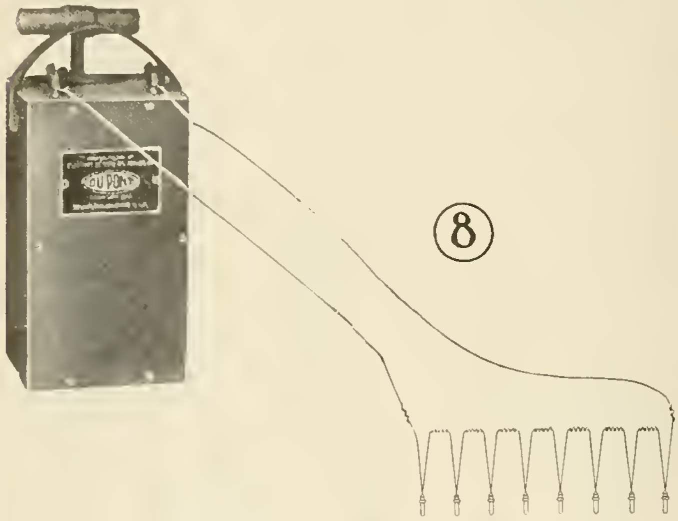


Fig. 8—Method of Making Connections for Electric Firing.

A half hitch with the wires themselves should never be taken around the cartridge on account of the liability of breaking the insulation and causing a short circuit.

In firing a blast by means of a blasting cap and fuse care should be observed to cut the fuse long enough to enable the operator to reach a safe distance. Fuse burns on an average of 2 ft. per minute and a variation of at least 10 per cent. should be allowed. In case of a misfire an examination should not be made for several hours, as detonations from hangfires often occur.

In using the electric method of firing the charges are connected up so as to make a complete circuit (see Fig. 8). The wires should never be connected to the blasting machine until everyone is at a safe distance and it is time to fire the charge or charges. The operator of the blasting machine should be at a safe distance from the blast and preferably in the open so as to be able to see and dodge any flying fragments that might come his way.

Electric blasting practically eliminates the danger of delayed shots or misfires and is especially recommended where the blasts are near where there is travel.

If it happened that the supply of electric blasting caps ran out unexpectedly, an improvised one may be made as follows:

Take a blasting cap and insert the open end in the cylinder of an electric squib and proceed the same as if it were an electric blasting cap. When firing, the spit of flame from the electric squib explodes the detonating substance in the blasting cap. This method is not recommended except in extraordinary cases on account of the additional expense and awkwardness in handling.

## USE OF WATER JET IN PUTTING DOWN PILES.

A committee of the American Railway Bridge and Building Association has been compiling information on the methods employed by the various railways in driving piles. Of the 56 railways reporting, about 50 per cent. stated that the water jet was in successful use under proper conditions. But one failure was reported and that was ascribed to the small size of the pump. The favorable conditions for jetting were considered to be sandy soil or gravel and for deep penetration.

The practice of the New York Central R. R. (Lines West) is typical of the railways reporting and is quoted below:

> We sometimes use a water jet to drive piles in sand, where it can be done advantageously without endangering the track, and where there is an abundant water supply and opportunity for the waste water to run away without causing trouble. For jetting we use a pump of sufficient capacity, placed near a stream or other body of water when at hand, or else on the driver tank, and pump from the tank to the jet. The object of the tank, which is kept filled from the nearest available supply, is to have an abundant quantity of water for quick use. We use a 2½-in. hose with a 2-in. iron pipe jet 30 to 40 ft. long, with the lower end drawn down to a diameter of about 1¼ in. to serve as a nozzle. The jet with the water running is lowered down into the ground, forcing the sand out as it goes down, to a depth which is sufficient to take the pile with just enough driving so it will stand solid after it is driven to place. For a 30-ft. pile we generally jet the hole so that the pile will go down about 25 ft. under the weight of the hammer, and can then be driven about 5 ft. to place.

The report states that jet pipes vary in size from 2½ to 1¼ in. and nozzles from no contraction on a 2-in. pipe to ½ in. at the end of a 1¼ in. pipe. On the Chicago & North Western Ry. a 2-in. pipe drawn out to a 1-in. nozzle, and somewhat longer than the depth to be penetrated is used. The upper end is fitted with an elbow, a nipple and a loose connection to a duplex pump of sufficient capacity to maintain a pressure of 100 lbs. per sq. in. in the pipe with an unobstructed flow through the nozzle. A separate line tied to the top of the pipe passes over a block at the top of the leads and down to the winch-head and furnishes means for readily raising and lowering the pipe. On the Southern Pacific R. R. the jet pipe is drawn out to a rectangular shape about ¼ in. by 2 or 2½ in. Some advantage is claimed for this shape when used in stiff material. Two jet pipes are used occasionally. The water pressure used varies from 100 lbs. to 225 lbs. per sq. in. and pumps with 3 or 4 in. discharge pipes are generally used. A large volume of water at moderate pressure is stated to give the best results.

A somewhat different type of jet wherein steam takes the place of water is in use on the Chicago, St. Paul, Minneapolis & Omaha Ry. This company uses a steam jet on a track driver when jetting is advisable, and has found it practical and economical to bore the piles and insert the jet pipe, so the full force of the jet is applied at the center of the point of the pile. A hole of proper size is bored in the center of the point and at an angle such that it comes out the side of the pile about 2 ft. above the point. The nozzle of the jet is inserted in this hole and allowed to go down with the pile. This method has been used and found very satisfactory where it was desired to drive falsework piles down to rock to support two heavy spans while piers were being rebuilt.

## CONSTRUCTING A CUT AND FILL PARK.

Work is now under way on the conversion of some 150 acres of level prairie on the west side of Chicago into a park having hills, a lake, play grounds, golf grounds, swimming pool, drives and other features. The scheme involves over 270,000 cu. yd. of grading. The excavated material is placed around the sides of the park forming hills 8 to 10 ft. high on which will be planted trees and shrubbery. A sketch of the proposed park is shown as Fig. 1.

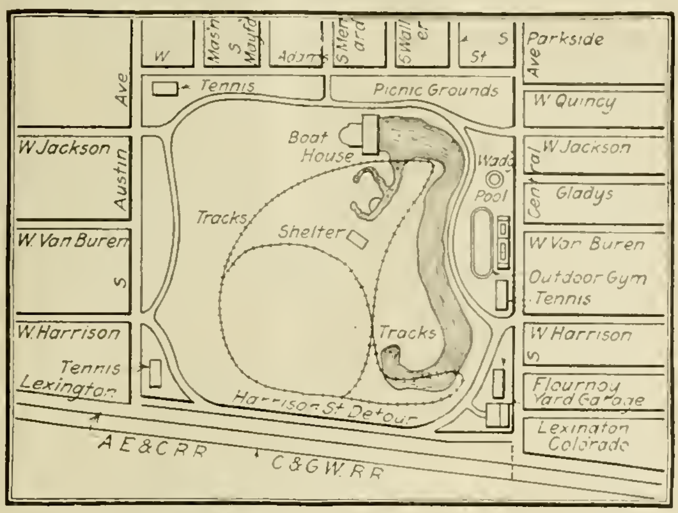


Fig. 1—Layout of Columbus Park.

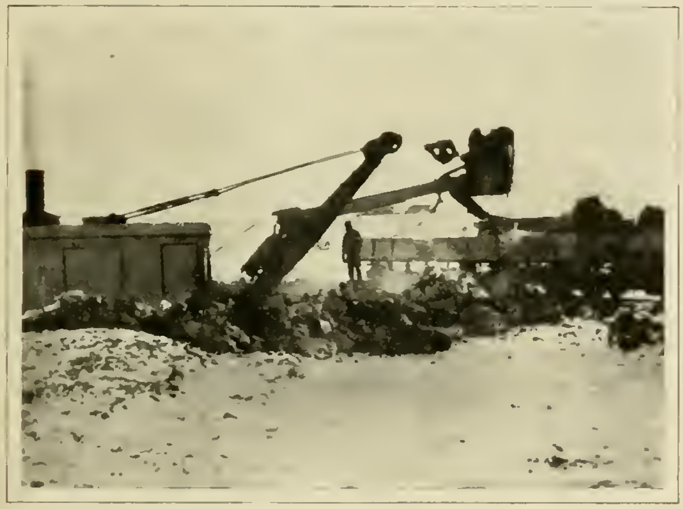


Fig. 2—Steam Shovel Loading Into Cars.

The soil consists of a thin cover of black dirt over hard clay, known locally as iron bound clay. The top soil is stripped off by means of New Era elevating grader pulled by a Reeves traction engine. The black earth is hauled by dump wagons and spread over other areas. A considerable portion will be placed on the slopes of the embankments.

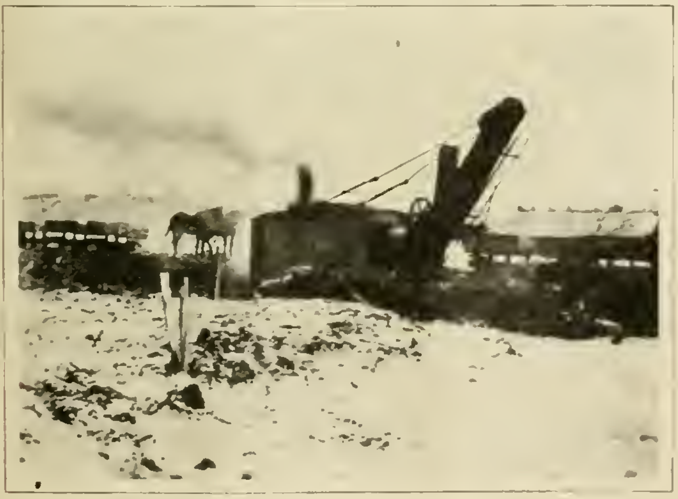


Fig. 3—Steam Shovel in 8-Ft. Cut.

The lagoon will cover about 12 acres, will have a water depth of about 6½ ft. and an average width of about 125 ft. The excavation for this is being made by two 15-ton revolving Erie shovels having ¾ yd. dippers. The spoil is hauled by wagons or small dump cars, depending on conditions, and is used for making the artificial hills at the sides of the park. The digging is in hard clay.

Fig. 4—Team Hauling Spoil Cars.

The dump cars are of the Western type, 1¼ cu. yd. capacity. They are hauled in 5-car trains by a team of horses. The track is 20-in. gage, made up of 20-lb. rails spiked to 36-in. long ties.

Fig. 5.

The first shovel began work in May. Its record for five months is as follows:

| | Actual time, days. | Loads per day. | Cu. yds. per 9-hour day. |
|---|---|---|---|
| May | 11¼ | 630 | 441 |
| June | 17⅓ | 987 | 987 |
| July | 24½ | 693 | 485 |
| August | 26½ | 954 | 668 |
| September | 22⅓ | 840 | 588 |

This shovel loaded into wagons and during July, August and September made many moves. Most of its cuts were 5 ft. to 6 ft. deep and 170 ft. to 250 ft. long.

The second shovel was placed in operation in August. It loaded into cars and had an 8-ft. cut 30 ft. wide that took from 8 to 10 days to make. The yardage moved by this shovel in August and September was as follows:

| | Actual time, days. | Load per day. | Cu. yds. per 9-hour day. |
|---|---|---|---|
| August | 19⅔ | 872 | 610 |
| September | 22⅔ | 968 | 678 |

The park is being built by day labor by the West Chicago Park Commission. A. C. Shrader, Chief Engineer and Superintendent of the Commission, is in charge of the design and the construction work.

## BELT CONVEYOR FOR TRANSPORTING GRAVEL TO STORAGE BINS.

An unusually interesting method is employed by the Standard Building Supply Co., of Grand Rapids, Mich., in transporting gravel to its storage bins. The arrangement is shown in the accompanying illustrations. The gravel is excavated from the pit by an Erie shovel and loaded into a hopper, from which it is discharged onto a belt conveyor. The hopper, as will be seen from Fig. 1, is mounted on wheels which run on a short section of track, thus making possible a wider range of operation for the shovel. The first section of the belt conveyor (See Fig. 2), is placed on skids and can be moved to the right or left by means of a bar. After passing up the first length of belt conveyor, the gravel is dumped onto the inclined conveyor and carried to the screens and then up another incline to the storage bins.

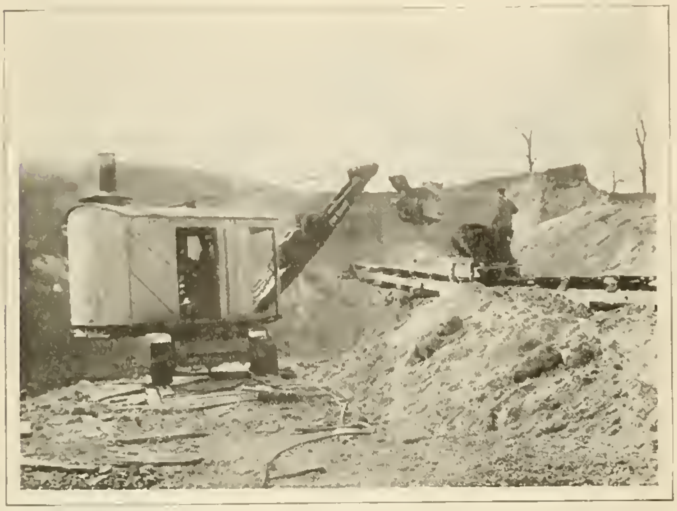


Fig. 1—Dumping Hopper.

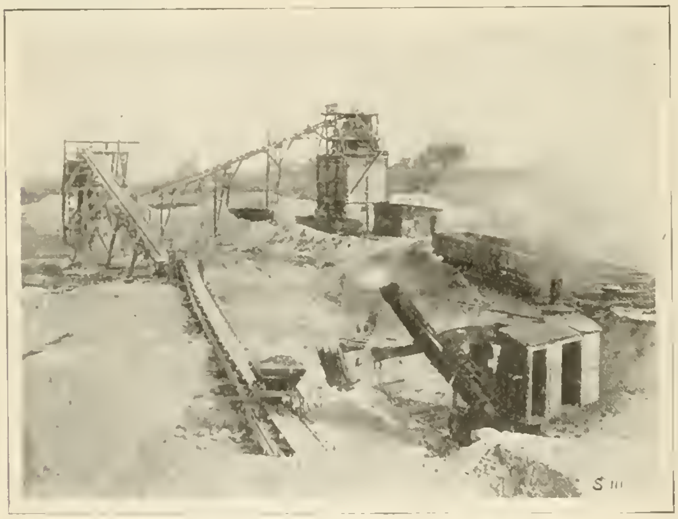


Fig. 2—System of Belt Conveyors.

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Good progress has been made with the construction of the Government railway in Alaska. About 49 miles of track have been laid from Anchorage, which, with the 71 miles of the old Alaskan Northern now in operation as far as Kern Creek, will make 120 miles of the 470 needed to connect Seward with Fairbanks. The tracks so far laid from Anchorage comprise about 6 miles southward toward Seward, 38 miles of main line northward to Fairbanks and 15 miles on the Matanuska branch and into the coal fields near by. Rail will be laid in the near future as far as Potter Creek, 15 miles from Anchorage, from which point the rock work will be undertaken during the coming winter.

## INSPECTION METHODS ON GOVERNMENT RIVER AND HARBOR WORK.*

All work is done under the personal supervision of the assistant engineer, and is rigidly inspected by as many inspectors as may be necessary. These inspectors are required to be constantly on the work while in progress, and very commonly live on the contractor's plant, the contractor being paid by the United States for the accommodations and meals thus furnished; under no circumstances must there be any money transactions whatever between the inspector and the contractor. When a job is begun the inspector is furnished with a blueprint map showing the layout of the work, a copy of the specifications, a loose-leaf notebook, a tape, stationery, and frequently a transit. The contractor is required to furnish him with a carefully marked sounding rod or chain, and must also provide tide gages, ranges, a boat and such assistance in the way of labor as may be required for sounding, setting ranges, etc.

Usually the first thing to do is to establish tide gages. The mean tidal range in the harbors ranges from 7½ ft. at the western end of the district to 2½ ft. at the eastern end; the maximum range is approximately twice the mean range. All dredging and breakwater work is referred to mean low water, at the place where the work is done, as zero; that is, the depth of dredging is so many feet below mean low water and the height of a breakwater is so many feet above it. It is customary on Engineer Department maps to omit the minus sign in front of all depths below the datum plane, and to prefix a plus sign to heights of points above mean low water. This is to avoid the constant repetition of the minus sign, by far the greater number of soundings, of course, being below the datum plane.

In each harbor and river under improvement there are permanent bench marks, established before the work is begun, their location being chosen, so far as practicable, so that a direct vertical measurement may be made with a rod or tape to the surface of the water at any stage of tide.

The tide gages used in dredging and breakwater work are boards about a foot wide and fully as long as the maximum range of tide at the place where work is being done, say about 15 ft. for the western end of the district, and about 6 ft. for the eastern end. These boards are usually divided into sections, each a foot long, painted alternately black and white, and numbered up and down each way from zero, which is placed 2 ft. or more from the bottom of the board, to allow for unusually low tides. The figures are 6 in. high, white on the black sections, and vice versa. With the aid of the bench mark the inspector sets his gage, usually nailed to a stake, pile or wharf, so that the bottom of the zero section is at mean low water. Generally several tide gages are set at different points along the channel or breakwater, so that one will always be in plain sight from the point where work is in progress. Careful attention to the tide gages is of the utmost importance, as upon them depends the depth that is made or the height of the structure that is to be built.

The next thing is to lay out the work and mark it, usually by ranges. For a breakwater or jetty a single line of ranges, marking the center of the structure, is generally used. These ranges are usually set from permanent transit stations on shore, and additional transit stations and bench marks are established on the structure as soon as a short section of it has been built, more points and benches being added at frequent intervals as the work progresses, so that its axis is determined by an accurate transit line, and its height by a line of levels.

In the case of a dredging job, the area to be dredged is laid out, frequently with the aid of a transit, from the data given on the blueprint, and is divided into longitudinal sections, corresponding in widths to the cuts which the dredge can make. This varies greatly with different dredges, ranging from 20 ft. for a small scoop, to 100 ft., or even more, in the case of a big pump or ladder machine. The inspector is usually aided in the laying out of the work by additional men from the office; sometimes it is done by a regular survey party in charge of a junior engineer. The cuts are generally marked by stakes or piles, on which are fixed flags or targets, so that they may be plainly visible. Sometimes objects on shore, such as church steeples, prominent trees, the corner of a house, etc., may be utilized, and frequently the precise location of the channel is chosen so that it will follow some natural range which will aid in navigating it after its completion.

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*From a paper, "River and Harbor Improvements in Connecticut," presented at the 32nd Annual Meeting of the Connecticut Society of Civil Engineers, by G. S. Verrill, U. S. Assistant Engineer.

Too much care can scarcely be taken to carefully lay out the work so that the channel as actually dredged will follow the lay out on the map, and so that the cuts will be parallel and of the same width throughout, so as to leave no ridges between them.

Beyond this point the duties of an inspector on dredging and breakwater jobs differ considerably, and we will consider them separately, taking the dredging first. After laying out the work, he must provide for measuring the material. If it is to be removed in scows, the scows must be carefully measured while empty and a table made showing the capacity of each when even full, and when slack by various small amounts, as 6 in., 1 ft., 1½ ft., etc. This is often quite a job of itself, and requires much care, as a very slight difference in some of the measurements of a large scow, such as the length, width, etc., may produce quite a large error in the total capacity. The scows should always be reasonably clean, and the doors tightly wound up when they are measured, and it is frequently necessary in the case of large scows that they be beached, so that reliable measurements may be taken of the bottom, which is under water when the scow is afloat.

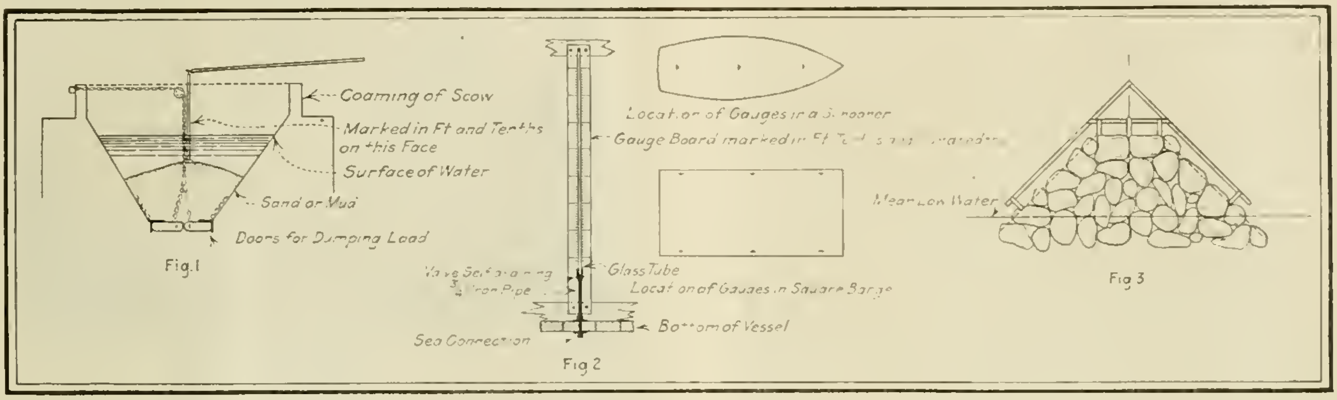

Fig. 1—Rod for Measuring Scow Load.

Fig. 2—Vessel Scales.

Fig. 3—Breakwater Screed.

If the material is to be handled by the hydraulic (suction) method, it is generally measured by carefully cross sectioning the bottom before and after dredging. This requires much care, and must be done by a party of several men. Various methods are followed. In the case of a comparatively narrow channel with shallow water or banks along the sides, so that stakes may be set to hold it, a carefully marked wire or wire cord may be stretched across at regular intervals, of 25, 50 or 100 ft., depending upon the uniformity of the bottom, and soundings taken from a boat at the marks of the wire. When the depth or other conditions are such that a wire cannot be conveniently used, the soundings may be taken from a float, so anchored that its location and movements may be easily controlled.

In any case, the soundings before and after dredging must be taken with such accuracy as regards depth and location as to correctly give the amount of material removed.

Measurement of material after being placed ashore is not usually satisfactory as showing the amount removed from the channel, for a considerable quantity is carried away in suspension, hence this method is not used in this district.

Having established the tide gages, laid out the work, and provided for measuring the material, the work and the inspector's troubles (for he has many of his own) are ready to begin. His most important duties are to see that the dredge is kept on line so that the cuts follow the ranges; to see that the specified depth is made, and to carefully measure the dredged material. He must also record the distance moved by the dredge each day on each cut, and plat it on his progress sheet; note the time when the loading of each scow is begun and finished; note all delays of 15 minutes or more, with the cause; and record the character of the material dredged, and the depth before and after dredging. At the close of the 10th, 20th and last day of the month he must submit a report giving all the data named above. He must also, as soon as practicable after the job is begun, make up and send in a description of the contractor's plant and force, and keep this up to date by additional reports each 10 days.

It is a common idea, sometimes shared by new inspectors themselves, that the job of a dredging inspector is a good deal of a cinch. But in reality there is plenty to keep him very busy.

Keeping the dredge on line means that he must be on deck nearly every time the dredge moves ahead, to see that she is properly lined up. Often he gives the signals himself.

Watching the bottom to see that the required depth is made takes a large part of his time, for he must sound across the stern of the dredge and along her sides very frequently, at every move if the material is hard. In fact the extent to which he uses his sounding rod or chain is a very fair indication of how well he is attending to his job. In addition, he must frequently get out in his skiff and sound ahead to keep track of the cutting bank; and behind, to be sure he has missed no lumps or ridges that may have been left. If any are found, the dredge must be moved back to pick them up. This causes loss of time for the dredge, and hence is often objected to by the contractor or his representative, and it frequently requires some little persuasion on the part of the inspector to get it done.

The measuring of the loads of the scows does not take very much time, but it must be done very carefully. And it is here that there is frequently a difference of opinion. When the scow is even full, there is little chance for argument; but if it is slack, as very often happens in the case of heavy material like sand and gravel, it is not so easy. In such cases the load is usually uneven, often partly or entirely covered with water. It is then necessary to carefully sound each pocket to determine how much—6 in., 1 ft., 3 ft., or whatever it may be—the load will level off below the top of the coamings. The inspector uses a rod marked in feet and tenths, and if the scows are large it is necessary to have such a rod fastened to another one by a hinge so as to be able to take soundings in the center of the pocket (Fig. 1). Having determined how much each pocket is slack, the actual load is easily obtained from the table.

The distance dredged is kept in various ways, such as by noting the distance the dredge moves past objects forming ranges, known as "cross ranges," nearly at right angles to the cut; by sextant angles from the dredge; transit or sextant angles from the shore; by a marked line arranged to pay out astern as the dredge moves ahead, etc.

All of these duties call for careful attention, and no small amount of tact. A good dredging inspector who will succeed in getting a good job, and at the same time not be constantly in a row with the contractor and his employes, is a scarce article and earns every cent of his salary.

After the dredging is reported completed, a careful examination of the bottom is made by a regular survey party, and if it is found that material has been removed from below the regular depth plus the allowable overdepth or leeway (usually 1 to 2 ft.) or from outside the prescribed limits, the amount of material thus removed is deducted from the final estimate. If any shoals, lumps or ridges are found, the contractor is required to remove them before final acceptance of the work.

The inspection of stone work, such as breakwaters, dikes, etc., is quite different from dredging work. Practically all structures of this class in this district are now built of riprap, which is paid for by the long ton, 2,240 lb. delivered and placed in the work. To measure it the vessels in which it is delivered are first carefully weighed in. These vessels are provided with from 3 to 6-gage glasses—glass tubes similar to the gage glasses of a boiler—with an outboard connection at the bottom, and provided with a scale (wood or metal) carefully marked in feet, tenths and hundredths (Fig. 2). Before weighing in, the inspector carefully ties in these scales so that their position cannot be changed without his knowledge. The vessel must be pumped dry and have on board only her regular fittings and equipment. The stone comprising the load is then accurately weighed on vitrified scales and readings are taken on each gage at frequent intervals as the loading proceeds, care being taken to trim the vessel as even as practicable at each reading. Often two more loads of each vessel are thus weighed in. From the results of this weighing, tables are constructed to give the load for each hundredth of a foot. Thereafter, when a vessel arrives at the work the inspector reads the gages before unloading begins and again when it is finished, and thus with the aid of his tables determines the amount of the load.

Although to look at a breakwater one might think it was simply a pile of stone, in reality much skill and care must be used in building it. If the water is deep it is often permitted that below a certain depth, say 10 or 12 ft. below mean low water, quarry run may be used, and this is sometimes dumped from bottom-dumping scows, several hundred tons at a time. The upper portion of the structure, or in shoal water the whole of it, is built with stones delivered and placed by derricks, one at a time, and this is the work that requires skill and careful attention on the part of the inspector and the contractor's employes.

The height of the breakwater, the width of the top, and the slope of the sides above water are commonly obtained by means of screeds which are set by transit and level so as to be a certain fixed distance, generally 1 or 2 ft. outside of the neat line of the breakwater (Fig. 3). By measuring from the line of these screeds, an inspector can readily determine whether any stone is slack or full.

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The Illinois State Civil Service Commission, Springfield, Ill., will hold an examination on Feb. 3 for the position of Junior Highway Engineer in the Illinois State Highway Department. The salary will be $75 to $120 per month and the examination is open to citizens of the United States. The applicants will not be assembled at examination points. Instead questions will be mailed and answers filled out by the applicants at their homes and returned to the Springfield office of the commission.

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## A TIMEKEEPER FOR EXCAVATING MACHINERY.

Every contractor has some system for recording the time of his employes. This shows, in a way, what his equipment is doing. It does not, however, give an exact record of the operating and idle time of his machinery. A device which, it is claimed, gives this result is now being used by many contractors. This is known as the Servis Recorder.

This instrument is a clock-like arrangement, which automatically records on a chart the entire operation of the machine to which it is attached. The record is traced by a stylus which is actuated by a pendulum. The latter swings when the equipment is actively engaged, but remains stationary during idle periods even though the engines are running. It is not disturbed by vibrations, however violent.

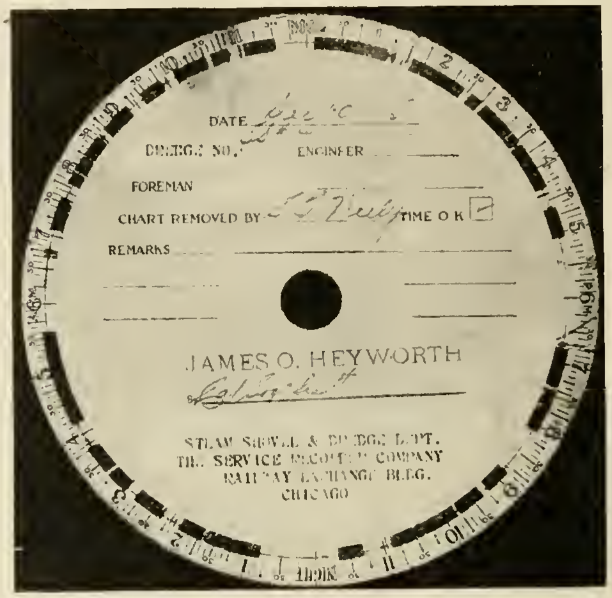


Fig. 1—Reproduction of Chart Showing Operations of Steam Shovel for 24 Hours.

The chart is fastened to a dial which revolves once every 24 hours and is driven by an 8-day 7-jewel watch escapement movement. The recorder is attached to steam shovels, dredges and drag lines without the use of flexible shafts, gears or other outside connections. On standard steam shovels and dredges it is usually placed on the boom. On revolving steam shovels and drag lines it is fastened against the side of the cab.

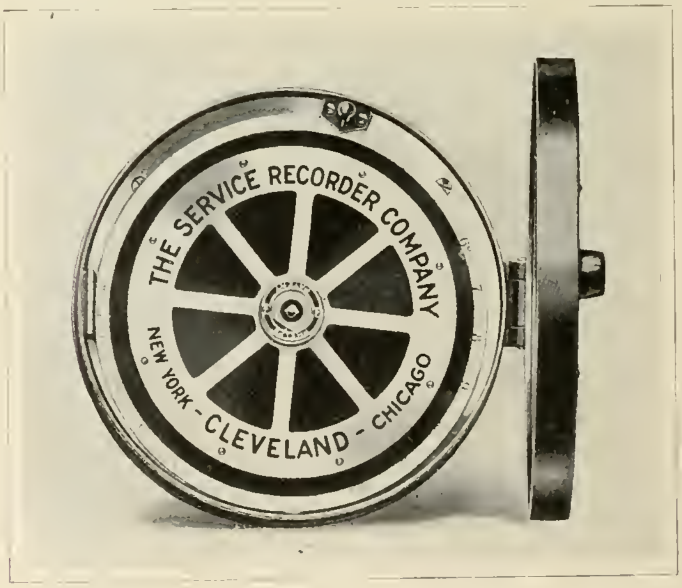


Fig. 2—Servis Recorder.

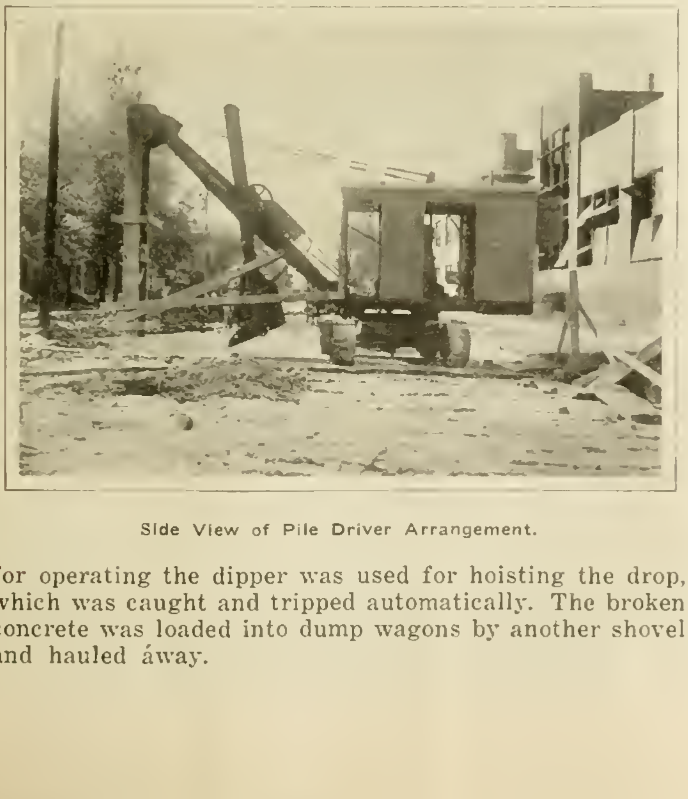
Figure 1 is a reproduction of a chart made by one of these instruments in use on one of the steam shovels owned by James O. Heyworth, Chicago, and operating on Section 1 of the Calumet-Sag channel near Blue Island, Ill. The chart shows clearly the entire operations for 24 hours. The broad heavy line indicates the actual digging operations and the narrow light line indicates the idle period.

These recorders also are used on commercial vehicles, either horse drawn or motor driven. They are manufactured by the Service Recorder Co., which has offices in the Railway Exchange Bldg., Chicago, Ill.

## PILE DRIVER ATTACHED TO STEAM SHOVEL.

A pile driver arrangement attached to a ¾-yd. Erie revolving shovel was used by Lenane Bros., contractors, in breaking up a concrete base on one of their street improvement contracts at Detroit, Mich. A chisel shaped drop was used to smash the concrete. Ordinarily this base would have been scooped up by the shovel and broken into slabs, but in this case the concrete was to be used for ballast and so had to be broken into small pieces. The cable for operating the dipper was used for hoisting the drop, which was caught and tripped automatically. The broken concrete was loaded into dump wagons by another shovel and hauled away.

Front View of Pile Driver Arrangement.



Side View of Pile Driver Arrangement.

## METHOD OF CONSTRUCTING THE CALVARAS HYDRAULIC FILL EARTH DAM.

The Calvaras dam of the Spring Valley Water Co., of San Francisco, Cal., is one of the largest hydraulic fill earth structures now under construction on the Pacific Coast. It will have a total height of 240 ft. above bedrock and will contain over 3,100,000 cu. yd. fill. At the present time the dam is completed to an elevation of 140 ft. above bed rock and contains 1,750,000 cu. yd. The methods employed in carrying out this work were described by Mr. G. A. Elliott, engineer, Spring Valley Water Co., in a paper read on Oct. 17 before the San Francisco Association of Members of the American Society of Civil Engineers. The paper, in greater part, follows:

The design of the dam calls for a height of 240 ft. above the bedrock, a crest length of 1,300 ft., a base width of 1,300 ft., and a volume of 3,100,000 cu. yd. Carrying out the plan to have an absolutely safe structure in view of the fact that its dimensions were greater than those of any other dam yet attempted, the upstream slope was planned 3:1 and the downstream 2½:1. To prevent seepage bedrock was exposed for a distance of 50 ft. on either side of the crest line and a trench excavated 8 ft. deep and 25 ft. wide. On the west abutment due to the presence of seamy rock, it has been necessary to carry this trench to a depth of 70 ft. The outlet work consists of a horseshoe shaped concrete culvert with an inside area of 234 sq. ft., following the course of the original stream channel. The unusual size of the culvert was made necessary by the fact that during the first year of construction it had to carry the winter floods with practically no head on the inlet. A reinforced concrete tower 234 ft. high, located at the inlet of the culvert, provides an outlet for the reservoir. The tower stands upon a hexagonal base 50 ft. across and 9 ft. thick, and has outside diameters of 28 ft. at the base and 13 ft. at the top. The wall thickness varies from 4 ft. to 18 in. The tower plans were prepared by Mr. A. V. Saph, and the design was predicated on the ability of the structure to withstand a possible earthquake shock with an acceleration of 6 ft. per second.

Work was commenced in May, 1913. It was necessary to complete, before the winter floods, the construction of the culvert and a dike on the upstream toe of the dam in order to divert the creek flow. This involved moving about 100,000 cu. yd. of cut and the placing of over 20,000 cu. yd. of concrete in the culvert. The work was finished a few days before the first flood. The concreting of the culvert took six weeks, an average of 500 cu. yd. per day.

Early in 1914 the hydraulic fill was commenced, and has been carried on to the present time. In the beginning 4-in. hose and 2-in. nozzles were employed in sluicing down the banks, but it soon became apparent that the greatest efficiency would be secured by concentrating the streams, obtaining thereby not only greater cutting effect, but also increased yardage, due to the greater carrying capacity of the larger volume of water. With the exception of the first few weeks, Hendy giants, supplied through slip-joint steel pipes, have been used in all of the pits.

Practically all of the hydraulic fill in the dam has been pumped. The location of only one of the eight borrow pits used was at an elevation sufficient to deliver the material by gravity. The distance of transportation has varied from 1,000 ft. to 4,500 ft. and the material handled has been gravel, sand, shale, sandstone and clay. The equipment used in the work consists of motor-driven centrifugal pumps. A 3-stage eight second foot centrifugal pump, direct connected to a 500 H. P. induction motor, is mounted on a barge in the reservoir above the partially completed dam. The water is pumped through 12-in. slip-joint steel pipes, and is delivered at the pit with a nozzle pressure of 75 lb. The size of the discharge tips varies with the material, depending upon the cutting force necessary to bring down the banks. Another station is located in the canyon below the dam, and receives its supply through a suction pipe laid through the outlet culvert. This installation consists of two units—one with a capacity of 8 second feet against 400 ft. head, and one of 4 second feet against 550 ft. head. The water from the smaller pump is delivered with a 75-lb. head at the nozzle and is used to cut the banks. Water from the second unit is delivered at the pit without head and simply gives a volume sufficient to carry the material to the dam. By dividing the pumping head in this way a considerable saving was affected in the power cost.

The jets are directed against the toe of the horrow-pit bank, which is undermined, causing it to cave in. This results in the soil being broken up and allows the water to carry it away. The soil-laden water flows to the lowest point in the pit, passing through a grizzly or screening device made of vertical 2-in. pipes set 4 in. apart. Rocks over 4 in. in diameter are screened out and passed through a rock crusher set just below the grizzly. From this point the material is pumped by a 12-in. mud pump driven by a 300 H. P. motor through a 14-in. slip-joint steel pipe to the toe of the dam. The grade of the floor of the pit depends upon the material, varying from 6 per cent. with fines to 20 per cent. in coarse rocky material.

The pipes discharge their contents on the outer edges of the toes. The coarser fill remains near the point of discharge, the remaining burden of the water being deposited automatically as the velocity of the stream decreases, until the pond is reached. Here the fine clay is settled in comparatively still water. The point of discharge is changed along the toes by the removal of successive pipe lengths, to maintain uniform relation between the widths of the dry banks and pond. Whenever possible pipes are removed from the end of the discharge line without interruption to the pumps, so that a delivery run across the toe is generally commenced from the end furthest from the pit.

The mud pumps will operate against a head of 80 ft. When the head exceeds 80 ft., a second pump is put in the line. The head on the mud pumps depends largely upon the character of the soil. With an excess of clay, the friction is compartively low, and the power required is a minimum. An example of this fact may be had with the present arrangement at Calaveras. In order to reduce interruptions to a minimum, duplicate units have been installed, so that should work be discontinued for any reason the crew can be immediately moved to another location. Two pits at the same elevation and the same distance from the dam are used alternately. One of these pits is composed of about 65 per cent. clay and 35 per cent. shale rock. In the other these percentages are reversed. When using the first pit one pump is sufficient. If the second pit is used, a booster has to be cut in and the power is doubled. It is difficult to ascertain with any degree of accuracy the value of the constant to be applied to the hydraulic radius and slope of the pipe lines to determine the flow owing to the impossibility of measuring the discharge. Such tests as we have been able to make indicate that with a 14-in. pipe line the loss of head is about 70 ft. per 1,000 as compared with 15 ft. per 1,000 for clean water, based on a flow of 8 second feet.

One of the problems encountered in the work was to reduce the wear on pumps and pipes. The velocity of the water and the character of material which it carries are the factors that affect the life of the carriers. Although a high velocity is desirable to secure the maximum carrying power of the water, it was found that the minimum velocity in the pipe lines which would keep the material in suspension caused the least wear on the pipes, and although the output decreased the resulting unit cost was lower. With the installation described above this critical velocity was 12 ft. per second. On an average the water carries 8 per cent. of its volume of material. All of the wear takes place on the bottom third of the pipe circumference. This feature is so pronounced that the coating on the interior of the line is not disturbed on the top two-thirds of the circumference even when the plate at the bottom is worn through. High carbon steel pipes are now being tried, and the result has justified the slight increase in initial cost. The pipes are turned twice during their life, enabling full use to be made of the metal.

The runners or impellers in the pumps are subject to excessive wear. Three kinds of material have been used —cast iron, cast steel and manganese steel. Manganese steel runners cost about six times as much as cast iron, but the cost per cu. yd. was almost cut in two by the use of the former. It was found that in some cases the manganese steel runners wore unevenly, becoming unbalanced and creating excessive vibration of the pump.

The yardage handled through the life of a runner varies with the character of the material pumped. It has varied from 30,000 with sand and gravel, to 200,000 with excessive clay and soft shale rock.

During the first year of sluicing the excess water in the pond was allowed to flow out through a vertical pipe in the center leading to the culvert. To give this pipe stability a double line was used, consisting of a 16-in. pipe set inside of an 18-in. pipe, the space between the two being filled with cement grout. It was found that as the length of this pipe increased it was susceptible to the movement of the clay ore. As a matter of fact on one occasion the upper end of the pipe moved some 15 ft. or about 30 degrees out of plumb. Although we were able to straighten it up, the danger of a re-occurrence with the possibility of the breaking of the pipe where it joined the culvert, allowing the escape of part of the clay ore was so great that this method was abandoned. A trench 4 ft. wide was cut through one end of the upstream toe and a bottomless flume constructed of 1-in. boards with 4-in. x 6 in. posts and 2-in. x 4-in. spreaders. Excess water from a pond is allowed to flow out through the box and runs down the slope of the dam which is riprapped up to the outlet to prevent erosion. To raise the level of the pond, rock and gravel is dropped into the cut to the required height for the width of the dry toes. The amount of clay contained in the discharge from the pond varies from 0.01 per cent. to 0.5 per cent. This depends upon the relative amounts of material delivered, clay sometimes being wasted in order to maintain the proper relation between the dry toes and the clay core, to insure the stability of the structure.

It developed after hydraulic operations had commenced that the available material contained an excess of clay, and that it would be necessary to either waste this excess or add coarse material by other means. A sandstone bluff opposite the downstream toe suggested the use of steam shovels and the desposition of this material on the outer slopes of both toes. Work was commenced early in 1915 with two steam shovels, the material being transported with wagons. This has resulted in a substantial increase in the width of the dry toes and has enabled sluicing to be carried on at a greater rate of speed, through eliminating the necessity for wasting in the pond discharge any of the clay ore.

In order to secure storage during 1916, it was decided that to obtain the maximum height of dam with the yardage to be deposited in the time intervening before the run-off period began, the lower toe should be moved toward the center a distance of 150 ft. This was done, leaving a bench between the final slope location and the temporary toe, which is now being filled by steam shovel work in the sandstone. This is now being done by contract, using a Model 65 Marion shovel and 12-yd. cars. The contract covers the placing of 375,000 cu. yd. of sandstone, this amount contemplating a fill varying from 150 ft. thick at the present elevation to 60 ft. thick within 40 ft. of the crest of the dam. It is the intention to continue placing sandstone on the upstream toe, unless future borrow pits develop an excess of rock and coarse material.

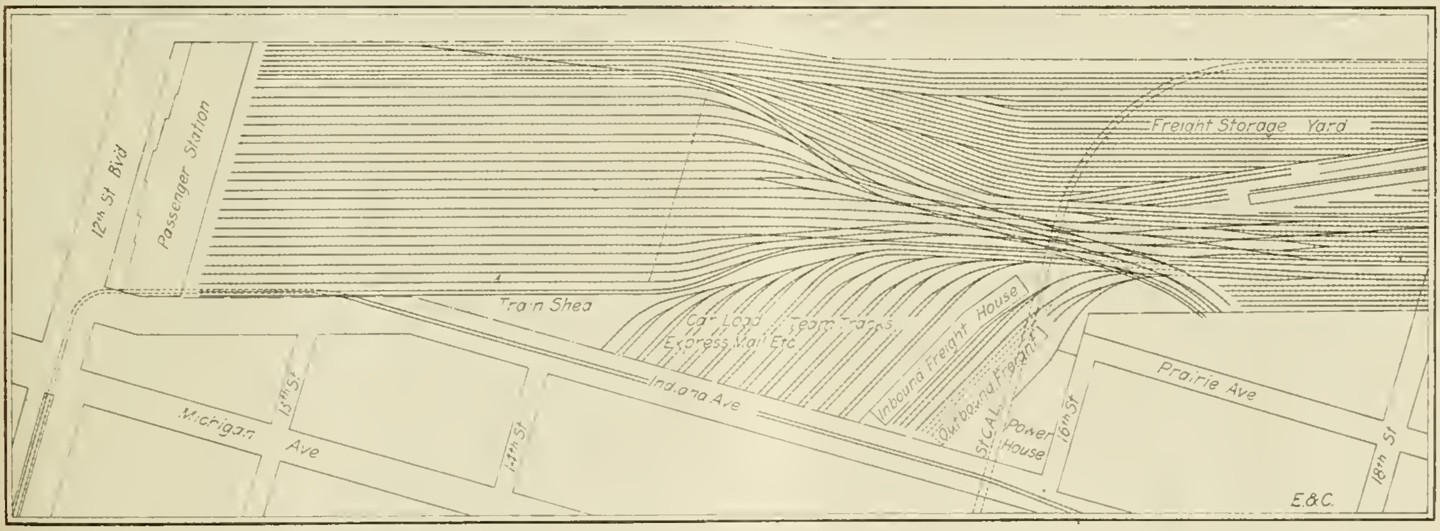
Comparatively few men are employed on the sluicing units. Two units are working two shifts each and the total number of men per unit per shift is 15, or 60 altogether. When it is considered that an average of 3,600 cu. yd. of material per day is transported a distance of 3,000 ft., with a crew of this size, the advantage of this method of excavating and placing fills is evident.

The cost of excavating and placing fills by the hydraulic method depends as much upon the character of the material as upon the cost of labor, construction materials and power. The relative coarseness of the material affects the head upon the pumps. The direct cost of sluicing the first 1,000,000 yd. of fill was about 25 ct. per cu. yd. This is the bare cost of the work and includes only the expense of pipes, pumps, motors, belts, power and labor used directly in the sluicing work. No interest, overhead, superintendence, insurance, or the prorated auxiliary costs of clearing the reservoir site, building and maintaining roads, trails, camp, etc., is included in this figure. In this connection, it must be borne in mind that the work accomplished so far has been on the base of the dam and that as the height is increased the unit cost of placing the sluiced fill will also increase.

At the present time the dam is completed to an elevation 140 ft. above bedrock, and contains 1,750,000 cu. yd. This leaves another 100 ft. to be added to the height and about 1,400,000 cu. yd. of fill to be placed. At the present rate of progress it is expected that the dam will be finished in 1918. Present indications are that the total cost will amount to about $2,500,000.

## THE PROPOSED ILLINOIS CENTRAL TERMINAL AT CHICAGO.

Representatives of the Illinois Central R.R. have submitted to the Railway Terminal Commission of Chicago an ordinance and report for the proposed lake front developments at Chicago. The plan calls for an ultimate expenditure by the railway of over $50,000,000. The ordinance, in brief, provides for the rebuilding of the entire Illinois Central terminal on a scale large enough to accommodate all railways entering Chicago, except those using the Chicago & Northwestern and Union stations. Under the plan it is proposed to have 24 tracks in the present main level from 12th St. to S. 16th St., with provision for the installation later of the same number of tracks on a lower level.



Tentative Track Layout for the Proposed Illinois Central Ry. Terminal at Chicago.

The main features of the ordinance and plan are understood to include the following:

An initial expenditure of over $10,000,000 for suburban electrification north of 67th St.; partial depression of the Illinois Central tracks along the lake front; opening of every half section street to the lake shore through subway or viaducts; changing of the present route of the St. Charles Air Line; an elevated railroad 30 ft. high for the Illinois Central, extending southwest from the St. Charles Air Line from a point near 16th and Clark Sts.; an underground loop for the electrified suburban service in Grant Park; running of street cars from the 12th St. viaduct down under Michigan Ave. out to the Field Museum and into the Illinois Central Depot, thence looping out by Indiana Ave.; connection of the Illinois Central with a dozen trunk lines through its southwest elevation; six main passenger tracks along the lake front south of 16th St., four suburban tracks, and additional freight tracks (at present there are eight tracks south of 16th St., six tracks running into the depot); erection of a low shed on the lake front two or three blocks long for railroad appliances, near 14th St.; provision for the Illinois Central to handle the freight for other railroads from the possible future new harbor near 16th St., at a rate to be agreed upon by an expert board; opening of 16th St. to Western Ave.; Illinois Central connection with the proposed Santa Fe Fruit Exchange at 22d St. and Archer Ave.

The preliminary general plans for the new passenger and freight station were submitted to the City Council of Chicago last September. These plans provided for a separation of grades commencing at 24th St. to carry the suburban passenger traffic at a level below the street surface and the through passenger traffic to a level above the surface.

The accompanying drawing of the track plan shows the upper track level, which is on a level with 12th St. as it will be when extended to Grant Park.

The headhouse will be four stories in height, and 190 ft. x 700 ft. in size exclusive of the concourse. There will be 24 tracks on the top deck of the terminal and 23 platforms, of which 12 will be used for trucking and 11 for passenger service. The platform tracks will have a length of 1,200 ft. and the Bush type train shed will be used. The middle deck will be used for handling mail, express and baggage, and there will be no tracks on this level. A portion of the bottom deck will be developed at this time for suburban facilities and will have two platforms and four tracks. Later on the balance of this level may be developed for through passenger train service.

## HAULING WITH TRACTOR-TRAILER OUTFIT.

Unusually difficult transportation conditions in connection with the hauling of ore from the Cardiff mines in the Big Cottonwood District of Utah have been successfully met by the use of tractor and trailers. The hauling outfit consists of a Model 36 Knox Tractor equipped with steel wheels 14 in. wide and a 5-ton ore body and four 5-ton non-reversible Troy motor truck trailers, equipped with regular steering apparatus, roller bearings and 36x 7-in. rubber tires.

The distance from the mines to the smelters in sandy is 16 miles, of which 9 miles are in a canyon and 7 miles across a valley. A rise of 3,050 ft. is negotiated in this 16 miles and in many places the grades are as steep as 16 per cent.

Before this method was adopted 11 demonstration trips were made.

The total tonnage of ore hauled during these 11 demonstrations was 272,660 lbs.; and although coal was not taken back on every return trip, a total of 27,080 lb. of coal was hauled back from the valley to the mines. The amount of coal hauled per trip ranged from 3,600 to 4,300 lb.

An average gas consumption of 21 gal. per round trip was registered, and the round trip consumption of oil averaged two quarts.

Two trips were made every 24 hours, the average time coming down being 3½ hours, and returning 4½ hours, which, with allowance of 1 hour for loading and unloading, gave 3 hours for oiling, taking on gas, and inspecting the machine. No repairs of any nature were necessary during the 11 trips.

The hauling contractor, the U. S. Transportation Co., is now making two trips every 24 hours carrying 15 tons to the trip.

Tractor-Trailer Outfit Handling Ore From the Cardiff Mines in the Big Cottonwood District, Utah, to Sandy, a Distance of 16 Miles.

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## PUBLIC SPEAKING IS PART OF ENGINEERING COURSE.

In order to develop the executive ability of its graduates, public speaking and "discussion classes" have been made a requirement of the Department of Engineering of Swarthmore College. The plan is described in a circular prepared by Mac P. Dowdell of the college.

The method employed in this public speaking course was to divide the class into sections of a half dozen students each. They studied at first an outline text written especially for the work in hand, but commenced actual practice in speaking almost with the first meeting of the class. Each department of the college furnished a list of subjects from which the students drew suggestions, and the instructors encouraged "talking shop"—at first only for five minutes at a time, but as proficiency developed, for longer periods, until 20-minute extempore speeches wound up the year's work.

The students named the conditions for their speeches in every case before they began, and were judged according to what they tried to do. "I will give a toast at a chamber of commerce luncheon," one student would announce, whereupon the remainder of the class would resolve itself into the group of supposed "lunchers" and would demand to be entertained, congratulated and convinced that the speaker was a "good fellow" and that his business was "all right." Salesmanship often occupied the attention of the class, and many a bill of merchandise was disposed of to critical boards of directors. An engineer interested in certain improvements on his father's farm, gave a series of talks on the construction of sanitary pig pens. Economics and political science students expounded the doctrines of every school of belief, from Herbert Spencer to H. G. Wells. Biologists spouted "survival of the fittest" and "evolution." After each speech the class spent a few minutes to discuss it and to decide whether it was a success or a failure.

While the public-speaking department solved one of his difficulties, Professor George B. Blessing, head of the Engineering department, worked out several problems in his own department. In order to develop executive ability among the men he introduced a system of shop accounting designed according to the principles of the Emerson school of scientific management. The men made their first acquaintance with this system through actually "ringing in" on the time clock. At first they did not take very kindly to it, and a second supply of "demerit slips" had to be ordered from the printer in a very short time; but the students soon began to be more careful, and "demerit slips" became a rarity. In operating the system the department provided that every man spend some part of his time in the shop office where he learned to see efficiency methods from the executive's point of view.

Professor Blessing also introduced "discussion classes" for all the junior and senior engineers. In these classes the students met their professors informally and brought up practical problems encountered in laboratory or field work during the week. The students did the talking, and helped one another to solve the difficulties. Quite frequently the professors absented themselves, or when they did attend, did more listening than talking. Comfortable leather upholstery of the engineering library furnished the environment for these classes, and perhaps helped to create the atmosphere of a conference between factory foremen and the shop superintendent.

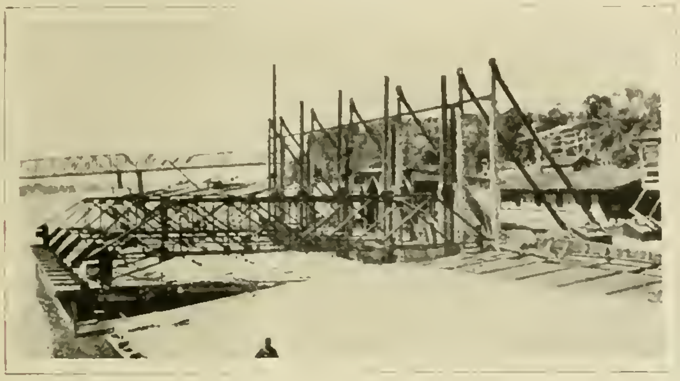
This is the system as thus far developed; but beginning next year a file of "personal-record cards" will enable Professor Blessing to keep track of every phase of the activity of his men. In addition to the record of a man's scholarship, these cards will provide space for "extra-curricular" activities. If he belongs to a fraternity the card will state that fact; if he becomes manager of the student weekly, or manager of an athletic team, or a player, his card will show that fact. At the end of four years the department will have an accurate index of the qualities of the man. Professor Blessing will be able to tell whether any particular man will be likely to make good as an executive, and will be able to place him in line for such a position; while, on the other hand, he will know whether his man is best suited to enter a field where technical ability alone will count.

It has taken six years to bring this work of Professor Blessing's to its present stage—too short a time to foretell just what percentage of improvement it is effecting. A judgment based on the qualities of the undergraduates themselves points to its success. The enthusiasm these men display toward their work is greater than the enthusiasm of any other group of students in the college. Recent graduates placed since this system has been working, have made exceptionally good records for the short periods of their employment. The houses which employed them are asking for more Swarthmore graduates. The next decade, however, will show the real results of this work. It will require a long period for the men now graduating to reach their high planes of earning power, and when they do, many of them will be found in the $15,000 class.

## SUBAQUEOUS CONCRETE REVETMENT FOR THE PROTECTION OF RIVER BANKS.*

Some three years ago, after service of a year or more on the Lower Mississippi River Improvement under the Mississippi River Commission, the writer was aroused to the thought of the feasibility of developing a reinforced concrete revetment to supplement or replace the willow fascine construction now employed. This thought was suggested primarily by the fact that the willow supply throughout the lower river is inadequate to meet prospective revetment needs; and secondarily by the obvious conclusion that a concrete revetment would be more effective and durable than a fascine structure, without necessarily being more costly. Again, the employment of concrete would result in an important reduction of manual labor, and be capable of development by units in such manner that very desirable flexibility of organization and of output would be possible.

Physical conditions on the Lower Mississippi are such as to render the revetment of its banks more difficult and costly, perhaps, than elsewhere in the world. The soils are alluvial and therefore exceeding friable; the depths in caving bends are extreme, at times exceeding 100 ft.; and the rapidity of flow is very severe, frequently topping 7 miles per hour.



Experimental Plant for Handling Concrete Revetment.

Revetment is provided for at present by the installation along a caving bank of a succession of fascine mattresses composed of bundles of willows bound together with strand and wire, each structure formed for an outshore width of at least 250 ft., and a standard length of about 1,000 ft. The latter dimension is occasionally exceeded, reaching at times 1,600 ft. Mattresses, of the size and character described, are held against the bank by an appropriate number and disposition of restraining cables, and in this position are ballasted with rock to the point of being barely afloat. Thereafter, by the rapid casting of man-sized stone from the barges, floated under control over the mattress, from the head downstream, sufficient burden is added to sink the entire structure as a unit to its final position.

These fascine mattresses have very admirably served their purpose in stabilizing the river bends to which applied. The relation of supply to demand, however, fixes the fact of the certain and early exhaustion of available willow growth under additional, or even present, revetment necessities. A substitute, or supplementary, construction by way of sawed lumber has frequently been suggested. In the view of the writer, however, the difficulties involved in handling a lumber structure of the required dimensions are of doubtful solution; satisfactory efficiency and durability are very uncertain, and desirable economies quite improbable.

It was accordingly conceived that a scheme might be devised whereby large sheets of concrete, or of blocks, suitably disposed and secured, could be satisfactorily handled to appropriate position and relation, upon the bed or bank to be revetted with the result of a more durable, more efficient, and more economical structure than now obtains. Many and varied suggestions looking to the employment of block and other forms of concrete revetment had been submitted to the Mississippi River Commission in the past, but none appeared to take intelligent account of the physical conditions and forces to be encountered, and hence were concluded to be inapplicable.

It was known that satisfactory, and, from the nature of the case, inexhaustible, deposits of sand and gravel for concrete purposes are spotted throughout the river, and that a suitable river run product can be inexpensively dredged.

Presenting the matter for the consideration of the Mississippi River Commission, the latter allotted $2,400 for "Experimental Revetment" in the fall of 1914, and based upon the results obtained thereunder, made a further assignment of $25,000 in the spring of 1915.

Under the allotment first referred to barges with inclined decks were prepared upon which were formed, and from which were launched, eight concrete slabs, such control being provided as could be applied by lines handled manually. The smallest of these slabs were 14x18.6 ft., of which five were formed and launched; the largest were 100x40 ft., of which two were constructed; a fifth slab of intermediate dimension, 18.6x19 ft., was also employed. All slabs were 4 in. in thickness, reinforced by strand and mesh, variously clipped and wired together.

These slabs were handled somewhat crudely, the barges utilized being out of all relation to the problem; nevertheless, the results verified the thought that concrete sheets of large area and small thickness, heavily reinforced, can be considerably "man-handled" and directed to the river bed in such manner as to insure their effectiveness for revetment purposes. A diver, employed to investigate the condition of two of the largest slabs, launched in inshore depths of 8 ft. and outer depths of 40 ft., reported the structures to be intact, subject to anticipated cracking, to be hugging the bottom closely, and to be generally in very satisfactory condition.

Under the allotment of $25,000 for further experimental work, a plant was developed consisting of two barges upon which to construct concrete slabs or mats, and a third barge upon which was mounted the necessary machinery and structural work to handle the same from their position of formation to the bed of the river.

The general proposition contemplated the formation of a concrete mat upon the inclined deck of a barge, the latter to be withdrawn under mechanical power after sufficient air hardening of the said mat, substitute support being simultaneously provided from a series of overhead trusses hinged upon a fixed mooring barge, and having wheel bearings upon ways of the barge withdrawn. During and after withdrawal, this substitute support would be arranged for by a proper number, disposition and attachment of lines running from the overhead trusses to trigger or trip connections with rings or loops formed in the mat. A situation would thus be developed wherein the latter would be suspended as a weight in water, between mooring and mat barges and might thereafter be lowered to position upon the supporting lines, or tripped to freedom therefrom. After tripping, control and direction to position would be provided by shackle connections from the upstream edge of the mat by trolleys mounted upon mooring barge spuds or by upstream and shore cables. By resetting the mooring barge to accord with desired relation or overlap of successive sheets, a continuous interposition would be provided between the river and the caving bank under treatment. In other words, the caving bank would be "shingled" with large concrete slabs, or mats, each of such size and weight as to insure successful resistance against destruction by the hydraulic forces to which subjected. The slabs were to be reinforced with but strand and mesh, such that maximum flexibility would be assured. Upon encountering check to their momentum in settlement toward final position they would crack into irregular areas and thus conform to whatever inequalities were involved. The several areas, however, would be held in juxtaposition by the imbedded strand and mesh, ample allowance being thus retained for satisfactory compliance with revetment requirements. Subsequent undercutting or erosion would be closely followed, due to the deficiency of cantilever value, resulting from the relation of area to thickness, such deficiency to be additionally regulated, if need be, by the creation of planes of weakness of any desired position and number. Satisfactorily long life would be assured by the galvanization to desired degree of any or all the reinforcement. The principal strand of the latter would be extended upon the upper, or high water bank, and securely anchored in its pavement. Such a revetment would thus be essentially monolithic from top bank to deepest water. To provide for maximum plant capacity, an accelerator would be sought to hasten the hardening of the slab sufficiently to withstand launching, final hardening to continue, of course, upon the bed or bank revetted.

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*From an article by Maj. E. M. Markham, U. S. Engineer, in the November-December issue of Professional Memoirs.

Experimental plant was designed to handle in the fashion described sheets 125x50x4 in. Slightly lesser sizes have been employed as a matter of precaution and of convenience.

The mat barges were constructed of such shape and buoyancy that with some 180,000 lbs. of water in a ballast compartment at the toe, the upstream edge of the mat starts about 12 in. above the water surface upon beginning mat barge withdrawal, becoming submerged within a few feet of the movement. The several suspension lines are fixed of such length as to take weight only after the same has been reduced to the extent of water buoyancy.

The mat barges were provided with inclined decks subdivided transversely by ways on 8 ft. 4 in. centers, between which platform sections were so mounted upon supporting timbers as to be readily lowered or raised by about 4 in. In the raised position, these platforms are flushed with butter, or launching boards, about 11 ins. in width, which themselves rest upon rollers inserted in the ways. After slab manufacture and upon sufficient air hardening the intermediate sections are dropped, the concrete structure thus resting entirely upon the buttter boards referred to. To launch a slab it is therefore necessary only to overcome the axle friction of the rollers, the butter boards moving with the slab and being recoverable under proper provision for that purpose. The ways are steel shod to receive the wheel bearings of overhead trusses.

Mechanical and structural equipment, mounted upon a wood barge 124x30x7 ft. consists of 35-HP. boiler, and double 7 by 7 in. engine, rigged with drums, winches, etc., of five intermediate trusses from which to suspend the slabs; and of two end trusses carrying sheaves and lines whereby to effect mat barge manipulation. All trusses are hinged near the downstream edge of the mooring barge, and have wheel bearings upon the ways of the mat barge. These trusses may be raised or lowered in unison through rigging to engine on the mooring barge, which as well provides power through suitable lines for the maneuver and control of the mat barge during its withdrawal. Suspension trusses are of 5-panel point Pratt type, spaced on 25-ft. centers, the interval being subdivided by side stirrups from each main truss. All trusses are cross-braced and interconnected by rods and shapes. Suspension is assumed from each panel point of both main trusses and stirrups, and is accordingly on square 8 ft. 4 in. by 10 ft. Five supporting lines across the mat are thus available, each involving 15 suspension points. The supporting lines consist of ⅜-in. cable, end-wedged on outside trusses, passing thence through two fixed and one movable sheave above each suspension point to drums of a shaft located on the center truss. Lines from one side pass under and those from the opposite side over the said drums. Prior to launching the lengths of these lines are fixed for support of the mat at desired submergence, and the end brake of shaft thereupon set. As the mat relatively lowers during the withdrawal of the barge upon which formed, the supporting lines come successively into play, and the total weight to be carried is accurately and automatically distributed to the several suspension points due to the character of the operation and to the fact that each suspension involves a movable sheave riding on a running line from center shaft to end trusses. No suspension, therefore, can assume more nor less weight than its due proportion. Under the arrangement described, the weight of a slab of 100 tons in air is necessarily so subdivided that the main trusses take each but slightly over 11½ tons, the suspension points somewhat less than .8 of a ton, and the supporting lines but about 900 lbs. As stated, conditions are such that this advantageous subdivision of large weight is both accurate and automatic.

As a precaution against uncertainty, or mishap, involving the safety of main plant, the strength of mat loops and of supporting lines is materially less than any element of the carrying structures. If, therefore, a trigger should fail to trip, or other untoward incident eventuate, the mat loop involved would part, or pull, or the suspension line break, before more serious result could develop.

The device employed at suspension points, suggested by the Bucyrus Co., of South Milwaukee, Wis., consists of a trigger attached to the housing of a movable sheave, and carries a pin held by a spring in what may be termed a "locked" position. To "hook up" a mat for launching, this pin is withdrawn by hand sufficiently to pass the mat loop between pin and jaw. The trip device remains in the "locked" position during the operation of launching, and while the mat is held in suspension. Connected to the tops of the several trigger pins are chains attached to the overhead trusses, and of such length as to retain slack when the running suspension cables have taken weight, all chains being adjusted for as nearly the same amount of slack as practicable. To trip or release the mat from suspension, it is therefore necessary only to throw the brake at the end of shaft on center truss, whereupon the weight of the mat itself overhauls all suspending cables, thus taking up the slack of all trip chains, whereupon trigger pins are pulled practically simultaneously, and the mat thus freed from any connection to the overhead structures.

To withhold the mat from movement with the mat barge, during withdrawal of the latter, shackle attachments are made from its upstream edge to trolleys designed to travel vertically upon spuds of the mooring barge. The mat, upon being tripped, will therefore continue under control of its attachments to these spud trolleys, connection being severed at any predetermined depth by the withdrawal of shackle pins. Upon release from suspension, the mat may be controlled likewise by upstream and shore lines of appropriate number and anchorage.

To prevent the slab during barge withdrawal from from attachments at its downstream edge to connections from attachments at its downstream edge to connection with overhead trusses near their wheel bearings.

Eight concrete sheets or mats have thus far been constructed and launched. They were reinforced by ½-in. strand, around the edges and on the lines of suspension and normal thereto; by 5/16-in. strand running diagonally through suspension points, and by triangular mesh over the whole area. Both strand and mesh were variously clipped and wired together. Suspension loops were formed of ½-in. round iron in the shape of hooks of uniform height and were engaged about the lines of strand at their several intersections.

The first mat handled was 50 ft. x 50 ft. x 3 in., weighing 62,500 lbs.; the second was 122 ft. x 47 ft. x 3 in., and weighed 215,000 lbs.; the last six have been each 122 ft. x 42 ft. x 3 in., weighing 192,000 lbs. Width was reduced from 50 ft. to 47 ft., in order to provide a somewhat longer bridle from spud trolleys to upstream edge of slabs. It was again cut to 42 ft. in order to reduce overhang above the first line of suspension, which theretofore had caused objectionable droop of the upstream portion of the mat.

The transfer of slabs from the mat barge to suspension was accomplished without incident involving difficulty or trouble of any character. The general scheme, in this regard, would appear to be unexceptionable. Under proper lubrication of launching rollers, the mat barge may be withdrawn with an insignificant amount of power, moving in fact entirely under the influence of current and of the weight of the mat, once the latter is started.

With two mats the tripping was somewhat ragged, due evidently to their inclination to the horizontal, in the position of suspension. In this respect, it developed that if a mat is released with material inclination either up or downstream, it will tend to move or skid rather too rapidly in the direction of its inclination. This fact led to the suspension of the last five mats in a slightly humped or cupped shape, provided for by fixing the mid-suspension lines at shorter length than those on either side. The up and downstream edges of these last five mats have thus been about 14 to 16 inches below mid-section at the time of their release.

The several slabs were launched over a shelving bank in inshore depths of from 8 to 18 ft., and outer depths of from 20 to 50 ft. All mats arrived at desired position within reasonable limits of error, as indicated by corner lines.

Three slabs launched during a high river have been partly exposed to view at lower stages. They are to all intents and purposes intact, being cracked only to the extent necessary for their accommodation to bank inequalities, which are closely and satisfactorily followed.

Reference was heretofore made to the fact that an accelerator for the hardening of concrete would be sought in the interest of increased plant capacity. To this end the Bureau of Standards was requested to investigate the subject, and to advise whether an inexpensive element was discoverable of the properties desired. As a result the bureau reported that the addition to the mixing water of from 3 to 4 per cent, by volume, of a saturated solution of calcium chloride would accelerate hardening to the extent of apparently giving "results in 48 hours equivalent to 75 per cent to 100 per cent of what we normally get in a month. We have tried this material out with a number of different cements and in different mixtures, and it has given very satisfactory results." The element named has been employed in the manufacture of six slabs with results consistent with the Bureau's findings, from which it is concluded that relatively thin revetment mats can be launched during "normal concrete weather" within 48 hours of their manufacture. The advantages respecting plant capacity are, of course, obvious. With respect to the degree of hardness required for launching, it should be observed that the concrete has no especial beam functions to perform, and that a reasonable amount of cracking or disruption is entirely acceptable. The concrete rests somewhat as an inert load in a hammock of metal and thus requires hardness sufficient but to hold it together against too general disruption after having attained its first set.

Under conditions of going work, the time required for handling or launching slab would necessarily be very small. "Hooking up" would be accomplished with a minimum of personnel and time, since the length of all suspension lines would be standard, and the few mooring and restraining cables involved would be mainly under steam capstan control. It is therefore conservatively estimated that with reasonably resourceful management, one handling plant should dispose of five slabs or more per day of ten hours.

Expenditures upon the experimental work outlined have been such as to suggest for comprehensive work a probable field cost of about 60 cts. per square yard. A comparable figure for willow fascine construction is from 70 cts. to 80 cts.

It will be noted that the plant on hand was designed to handle continuous concrete sheets 125 by 50 ft., but that slightly lesser sizes were employed. The only case known to the writer where bank revetment requires an outshore dimension in excess of 125 ft. is on the Lower Mississippi River, where, as stated, willow fascine mattresses are installed of a width of at least 250 ft. Concrete revetment in single sheets of this latter width is believed to be entirely feasible along the lines described, since the additional size involves no essential complication beyond the requirement of floating and other plant to scale, still within the limits of practicable construction and maneuver. The launching, suspension and release of such slabs would not increase unit stresses in any element of the operation. Additional outshore dimension would simply be met by additional supporting trusses and suspension points, each carrying no more nor less than its due proportion. Similarly, no physical nor mechanical consideration militates against the handling of a slab exceeding the 50-ft. dimension, though a limit in this direction would soon be reached by reason of excessive mat barge width, as well as the rapid increase of truss weights and stresses, due to additional spans. However, a slab of 50 ft. or thereabouts should be suitable and economical for the class of revetment involved.

The use of heavily reinforced concrete sheets after the manner described is not necessarily confined to bank revetment. They may be employed in any situation around or about the base of a structure to resist undercutting or erosion. Special arrangements for handling sheets in such situations would be required, the bulk of which, however, would doubtless be well within the field of reasonable resourcefulness and ingenuity.

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## TRACTIVE RESISTANCE TESTS WITH AN ELECTRIC MOTOR TRUCK.

The Research Division of the Electrical Engineering Department of the Massachusetts Institute of Technology during 1915 conducted an investigation of tractive resistance of urban roads to a motor delivery wagon equipped with solid rubber tires. The results of the tests are described in a recently issued bulletin, from which the matter that follows is taken.

The subject of the research was to determine the resistance, including air resistance, offered to an electric truck, by level urban roads of different surface varieties, at standard truck speeds not exceeding 25 km. (15.5 miles) per hour. For this purpose, the output of the storage battery on a test truck was measured, for both directions of travel, over standard road beds, at different controller speeds. From this output were deducted all the corresponding electrical and mechanical losses in the truck mechanism, as determined by laboratory tests. The remainder of the output was consequently attributed to (1) road- (2) air- and (3) wind-resistance. The wind resistance was eliminated by averaging the results for both directions of running, leaving as the final result the sum of the road and air resistances.

By "road resistance" is meant the horizontal force required to pull the truck, assumed as internally frictionless, over the horizontal road, in the absence of air. By "air resistance" is meant the horizontal force on the truck required to overcome the resistance of the air, assumed as quiescent in the absence of the truck. By "wind resistance" is meant the horizontal force on the truck necessary to overcome the resistance of the wind velocity, or that velocity of the air with respect to the ground which exists in the absence of the truck.

A 1,000-lb. (450-kg.) worm-drive, single-reduction electric truck, or delivery wagon, was placed at the disposal of the Research Division for the purpose of test. Its specifications are as follows:

Load capacity 1,000 lb. (450 kg.), equipped with one d-c. series motor.

| | | |
|---|---|---|
| Overall length of frame | 4,280 mm. | 168½ in. |
| Width of frame | 890 mm. | 35 in. |
| Wheel base (i. e., distance between centers of front and rear wheels, when front and rear axles are parallel) | 2,730 mm. | 107⅝ in. |
| Wheel gage | 1,470 mm. | 58 in. |

The total weight of the truck, including motor, battery and body, but without load or passengers, was 4,200 lb. (1,910 kg.). Each of the four wheels was equipped with one solid rubber demountable tire (manufactured for this type of delivery wagon) rated at 36 in. by 2½ in. (91.5 cm. by 6.35 cm.), and actually measuring about 35 in. (89 cm.) tread diameter, and 2½ in. (6.35 cm.) width of base. The brakes were of the internal expanding type on each rear wheel.

Typical results for all classes of urban roads tested are summarized graphically in Fig. 1, and numerically in Table I. It appears that there are three principal elements which determine the tractive-resistance-speed curve for unit weight of a given vehicle, within the range of conditions covered by this test:

(1) A constant resistance, see curve 1, Fig. 2; the mag-

nitude A of which depends on the lack of resilience of the road surface and wheel tire material, i. e., on the energy losses due to displacement of tire material and road-surface material. This constant element A would be encountered upon a smooth level road of the particular type considered, in the absence of impact, air, and wind resistances.

(2) An increasing resistance with increasing speed, due to impact losses (curve 2), which results from lack of smoothness of road surface; losses of this nature are usually known to vary approximately as the second power of the velocity at impact; and

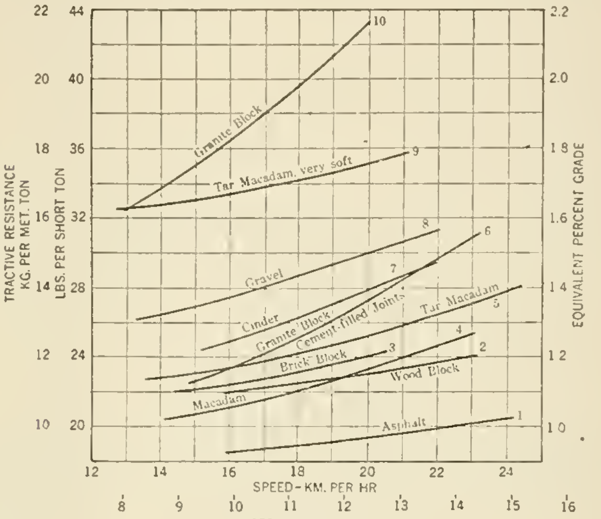

Fig. 1—Summary of Traction Resistance Tests.

(3) An increasing resistance with increased speed, due to air pressure against the front of the vehicle, curve 3, which resistance is known to depend, roughly, on the second power of the speed. The sum of the three curves for items 1, 2 and 3, for the case of asphalt roads, results in curve 4. The constant resistance (1) may be briefly called the displacement resistance, item 2 the impact resistance, and item 3 the air resistance. The displacement resistance is low for hard pavements and high for soft pavements (of low resilience). The impact resistance is very marked in granite-block roads, as already mentioned. The air resistance, at any definite velocity, is the same for all curves; because the air-resisting parts of the truck were left unchanged throughout the tests. For an asphalt road in poor condition, at a speed of 20 km. per hour (12.4 miles per hr.) the displacement resistance is 0.84 per cent, the air resistance is 0.11 per cent, the impact resistance 0.20 per cent and the total 1.15 per cent equivalent grade.

The displacement resistance of a road manifestly varies, not only with the type and surface quality of the road, but also with the type, dimensions and quality of the tires on the wheels of the vehicle. In the tests here reported, the same tires were used throughout, and they remained in substantially the same condition.

The impact resistance of a road manifestly depends not only on the type and surface quality of the road, and the sizes of its irregularities; but also on the type, dimensions and quality of the wheel tires, the weight of the truck, and the quality of its springs.

The air resistance per unit weight of truck manifestly depends upon the weight, dimensions and shape of the vehicle, as well as on the speed of the vehicle relatively to the surrounding air.

The wind resistance per unit weight of truck manifestly depends upon the weight, dimensions and shape of the vehicle, as well as on the direction and velocity of the wind and the velocity of the vehicle. It is assumed that at low wind and vehicle speeds, like those here considered, only that component of the wind which is in the direction of the vehicle's path needs to be taken into account, and that the mean of the wind resistance in opposite directions, along the road, is zero.

### Summary of Conclusions.

The following conclusions are indicated from the preceding results: as confined to urban roads, with a solid rubber tired motor truck between the speed limits of from 13 to 25 kilometers per hour (8 to 15.5 miles per hour).

(1) The over-all efficiency of the test-truck mechanism, as described in this report, between battery terminals and rear-wheel treads, reached a maximum value of about 78 per cent, under the most favorable conditions.

(2) The mechanical efficiency of transmission from motor shaft to rear-wheel treads, for the truck tested, shaft-driven through a single-reduction worm gear, was found as high as 90 per cent.

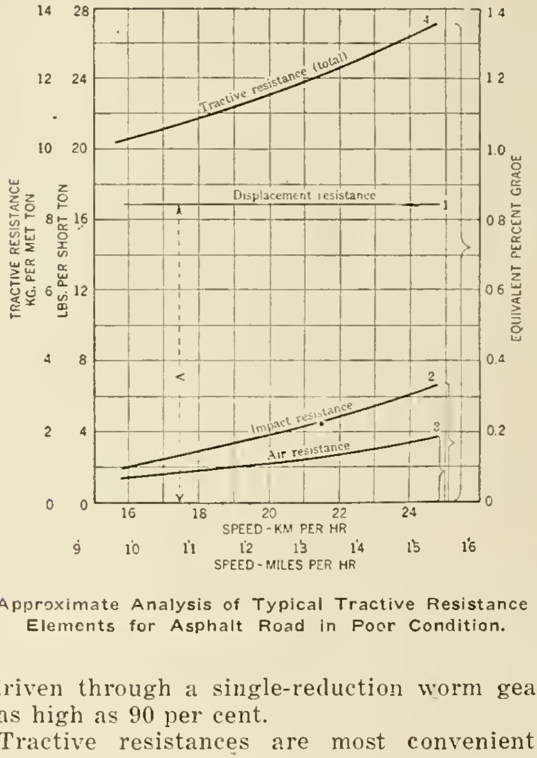

Fig. 2—Approximate Analysis of Typical Tractive Resistance Into Its Elements for Asphalt Road in Poor Condition.

(3) Tractive resistances are most conveniently expressed as an equivalent percentage grade; i. e., a level road of definite tractive resistance may be regarded as a road of zero tractive resistance, but rising uniformly x units in 100 units of road length, or having an equivalent grade of x per cent.

(4) Under the conditions of these tests, the tractive resistance on level roads, in the absence of wind, is com-

TABLE 1.—SUMMARY OF TRACTIVE RESISTANCES OF DIFFERENT URBAN ROADS AT DIFFERENT SPEEDS.

All tractive resistances are expressed in equivalent per cent grade.

| Road. Type. | Condition. | Equivalent per cent grade. at 16 km./hr. (10 miles per hour). | Equivalent per cent grade. at 20 km./hr. (12.4 miles per hour). | Per cent increase in tractive resistance from 16 to 20 km. per hr. | Comparative tractive resistance factors referred to asphalt roads. at 16 km./hr. | Comparative tractive resistance factors referred to asphalt roads. at 20 km./hr. |
|---|---|---|---|---|---|---|
| Asphalt | good | 0.93 | 0.97 | 4 | 1.0 | 1.0 |
| Asphalt | poor | 1.03 | 1.16 | 11 | 1.11 | 1.20 |
| Wood block | good | 1.10 | 1.15 | 5 | 1.18 | 1.18 |
| Brick block | good | 1.12 | 1.21 | 8 | 1.20 | 1.25 |
| Brick block | slightly worn | 1.14 | 1.27 | 11 | 1.23 | 1.31 |
| Granite block | good | 1.83 | 2.16 | 18 | 1.97 | 2.23 |
| Granite block with cement joints | good | 1.16 | 1.37 | 18 | 1.25 | 1.41 |
| Macadam, water bonded | dry and hard | 1.06 | 1.17 | 10 | 1.14 | 1.20 |
| Macadam, water bonded | fair, heavily oiled | 1.63 | 1.76 | 8 | 1.75 | 1.82 |
| Macadam, water bonded | poor, damp some holes | 1.65 | 1.89 | 15 | 1.78 | 1.95 |
| Tar macadam | good | 1.17 | 1.27 | 9 | 1.26 | 1.31 |
| Tar macadam | very soft | 1.67 | 1.76 | 5 | 1.80 | 1.81 |
| Tar macadam | many holes, extremely poor, soft | 2.38 | 2.75 | 16 | 2.55 | 2.85 |
| Cinder | fair, hard | 1.25 | 1.39 | 11 | 1.35 | 1.43 |
| Gravel | fair, dusty | 1.37 | 1.50 | 9 | 1.47 | 1.55 |

posed of (a) displacement resistance, (b) impact resistance, and (c) air resistance.

(5) The displacement resistance varied from 0.85 per cent equivalent grade, for a hard, smooth asphalt or bituminous concrete to 1.6 per cent for a very soft tar-macadam road, and was practically constant, for all speeds considered, on any given road.

(6) The impact resistance increases with the velocity, with the total weight of vehicle, and with increasing road-surface roughness. In these tests, the impact resistance of good asphalt or bitulithic or other smooth pavement, was practically negligible, and reached its highest values on granite-block roads with sand filled joints, and on badly worn macadam pavements. The rate of increase of impact resistance with speed was most marked on the roughest roads.

(7) At the vehicle speed of 20 km. (12.4 miles) per hour, the air resistance for the vehicle tested, assumed to be dependent only on the speed, was roughly 0.11 per cent equivalent grade; i. e., from 4 per cent of the highest, to 12.5 per cent of the lowest, total tractive resistance.

(8) The following urban pavements are numerated in the order of their desirability for vehicle operation from the point of view of tractive resistance at 20 km. (12.4 miles) per hr., as found in this investigation. (1) asphalt, (2) wood block, (3) hard, smooth macadam, (4) brick block, (5) granite block with cement-filled joints, (6) cinder, (7) gravel, (8) granite block with sand-filled joints.

(9) The equivalent grade at 20 km. (12.4 miles) per hr. of a badly worn city macadam road, was found to be nearly three times as great as that of the best asphalt road tested. This means, at this speed, a consumption of energy at wheel treads, of nearly three times as much on level poor macadam roads as on good level asphalt roads.

(10) Increasing the gross weight of the vehicle by 12 per cent, through load, was found to have no effect on tractive resistance within the observed speed limits for smooth roads in good condition; but on rough roads, a distinct increase in tractive resistance with this extra weight was observed.

(11) The presence of a layer of dust, say 1 cm. thick. on a fair macadam road, was found to increase the equivalent grade of tractive resistance, at all tested speeds, by about 0.15 per cent.

(12) A freshly tarred and therefore very soft tar-macadam road was found to have an increased tractive resistance equivalent, at substantially all tested speeds, of about 0.5 per cent. The tires in this case sank about 0.8 in. (2 cm.) into the road bed, the gross car weight being 2,140 kg. (4,710 lb.).

(13) The total range of tractive resistance equivalent grade covered in the tests, fas from 0.93 per cent on the best asphalt road, at lowest speed, to 2.7 per cent on the worst macadam road, at nearly the highest speed.

## MARKETING ENGINEERING ABILITY.*

The engineering profession has grown so rapidly and the demands upon it have been so great during the last decade that too little opportunity has been offered its members to look to the right and to the left in order the more readily to correlate its problems with the world of commerce, art, jurisprudence and the humanities with which they are necessarily so closely affiliated.

Engineering schools have developed satisfactorily, it may be said, the technique of engineering training. Engineering ability per se is not to be seriously criticised, but rather the marketing of that training in the public mart of twentieth century demands.

Coal of very high heating value may be purchased at less than $1 per ton at the mines. It is the placing of the coal under the boiler in a distant city that contributes most to the shock now associated with the average coal bill. The energy of falling water is thought to be a free gift of nature in the distant mountains, and so it is; but the competitive market in the metropolis finds the energy quite as dear as that produced from coal in the steam turbine. It is the marketing process, therefore, that calls forth the capital to conserve the waterpower cf the wilderness and to build the transmission lines over almost inaccessible territory. The average young engineer of today fills all too well a closely analogous position. He has the latent technical ability, but lacks the wherewithal to provide that ability with the handle which the layman, the business manager and the town council must necessarily grasp if the engineering profession is to be elevated to the position occupied in the public mind by the physician and lawyer.

It will be granted that the average engineer is technically well trained. Graduates of technical schools of recognized standing are rightfully assumed to be sufficiently familiar with the fundamentals underlying the branch of the profession in which they have decided to specialize. The employer and the public, however, justly demand more than this relatively small portion of the qualifications necessary for engineering success. The importance of such qualities as good habits, self-reliance, industry, honesty, punctuality, initiative, system, popularity, etc., which are not directly reflected in the grade a student may make in school, might be considered at considerable length. It is the purpose of this discussion, however, to focus your attention upon those attributes only which will be recognized as indispensable, although too often rusted, tools which must not only be firmly grasped, but wielded skillfully in marketing ones technical ability. Nor is it to be inferred that the object is solely to secure more salary; for an endeavor will be made to convince the younger engineers in particular, that the success and enjoyment of life for which everyone upon this earth is striving are not measured in dollars and cents alone.

But you inquire, "How is this bond between the engineer and the employer or the public to be strengthened, and how may this organization assist in this worthy endeavor? First, it may be said, convince the young engineer of the importance of good written English and the necessity of clear and concise verbal presentation of his recommendations to a non-technical individual or audience.

Let your statements acquire the valuable qualities known as conciseness and brevity. Webster makes these two words synonymous. Abe Martin says, however, "A synonym is what one writes when he is unable to spell the correct word." It seemed advisable, therefore, in this case, to use both terms lest someone quote the Indiana wit by way of criticism. Every engineer will appreciate the inspector's report which listed the fabricated steel as 1 G 1; 1 G 2; 2 F B 1, etc., in contrast to that of another employe who returned with the statement that he found "Six big pieces and a lot of little pieces." It has been well said, "You can please, you can plead, you can instruct, you can command or you can rebuke, in each case with the right use of words, and the right degree of emphasis, if you can use correctly the English language."

Whereas a mastery of both spoken and written English is more readily recognized as a vital agent which the successful engineer must command, a thoroughly knowledge should be acquired of the business principles with which his audience is too often more conversant than himself. Who shall interpret into the language of dollars and cents the estimates and findings of the engineer? Can anyone but him analyze as intelligently the valuations upon which the corporation is to base its rate schedules? Surely no one will question the justification of such a one suggesting to commission or court the fair and equitable gross income which should be allowed a railway corporation in order that it may pay a reasonable dividend upon its stock, when he is perhaps more conversant than anyone else with the construction, operating problems and costs of the particular utility in question. But the average young engineer knows little or nothing about rates, dividends, capitalization, stocks, bonds, etc. But what is worse, many consider it none of their affair. Such are likely to make an adverse criticism of the status of the engineering profession their first matter of business.

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*From an address by C. Francis Harding, Professor of Electrical Engineering Purdue University, delivered before the American Association of Engineers. The address is printed in full in The Monad, the official organ of the Association.

An estimate of the cost of an engineering project often forms the connecting link between the business world and the engineer. The business manager, the banker, courts and commissions judge the engineer by that portion of his work with which they are familiar, i. e., estimated costs of construction, court testimony or appraisals of property. One commissioner in particular in a public address has severely criticised the engineering profession in general, because two or three engineers varied by a margin of 10 per cent upon a $7,000,000 appraisal in which "going value" entered as a large factor. He argued that engineering was an exact science, and that unless the estimates of engineers could be made as exact as the science they represent, the profession was at fault. This example is quoted, not because of the justice of the criticism, but rather to indicate the basis upon which the profession as a whole is often falsely judged. Engineering was in this case shorn of its art, and the important element of personal experience behind the judgment of able engineers was left out of consideration.

Accounting practice and the proper treatment of depreciation reserves should be matters of common knowledge to the engineer. Who can say but what many of the financial disasters in the railroad history of the country might not have been avoided had the engineers been sufficiently cognizant of the reserves which should have been set aside to provide for the evil day in which the depreciation curve, which has gradually been recording the decay of equipment, suddenly lowers the valuation of the property by leaps and bounds? Should not the young engineers who will soon be estimating the operating expenses of electrification in Chicago, for instance, know something of the effects that an error in calculation or judgment may have upon the dividends which such a road may pay upon invested capital?

Business knowledge, however, even when coupled with a command of one's mother tongue, would fall short of the market demands upon the engineer without the necessary tact which must be exercised in all relations with the public. In a recent investigation made by a sub-committee of the National Electric Light Association, of which the speaker acted as chairman, the following significant statement was submitted by one of the prominent managers of the west:

> It is my opinion that tact is one of the most important things in the public utility business today, if not the most important. Tact and the habit of accurate thinking are essential, and I would say we must add to these a good allowance of energy. My observations in the whole northwest lead me to believe that most of the executive failures in this part of the country were due to lack of tact, and also to lack of ability to think rapidly. A technical graduate is too often inclined to follow strictly the letter of the law. This is because he has to deal so much with absolute natural laws which could not be tinkered with, whereas the executive and the commercial men have to deal with human beings, who, as far as I can discover, do not follow any laws at all.

The executive quite often fills the gap between the engineering department and the board of directors of the public. He acts as the buffer to receive the rough edges of the average engineering report, and to polish its surfaces that they may make better contact with the layman and the financier. Unfortunately he must frequently stand upon the fence picking the rough burrs from the tree of scientific investigation which he must laboriously open before the tender kernels of opportunity for investment are disclosed. The term "executive ability" has come to mean "marketing ability" in many corporations. It is a comprehensive quality involving many of the factors previously discussed. It has been well defined as "The ability to get others to do what you wish done while they at the same time are doing what they wish most to accomplish."

It was said of the late George Westinghouse:

> He is in control of enormous manufacturing companies in both hemispheres. The world is his field. No routine duties in any of his score of companies sap his energy. He thinks, others act. More than that, he inspires, an hundred think, ten thousand act. Some of his great spirit filters down through all of the organization, yet each man has his area of responsibility, in which he is perfectly free to follow his own work in his own way. Such a policy develops men, broadens them, fits them for higher duties, and by the same means secures the realization of a great man's ideals. It is using other men, including their wills, in the execution of one's plan.

Yet George Westinghouse was an engineer, first last and always. There are many such in executive offices in this day. The number is rapidly increasing. Whereas we may grant for the sake of argument, the claim of skeptics that executive ability is born and not made, it must be admitted that such a quality is often latent and lies dormant for years in many a human system. It is within the power and very much the duty of this organization to awaken such latent energy among its members and lift those by their own bootstraps, as it were, who have the necessary qualities previously outlined, or, even better, the ambition and initiative to develop such attributes, out of the ruts of the drafting room and record cases into the chair of the superintendent and manager. This organization can do much to place the engineering profession upon a high ethical and cultural plane if it will hitch its wagon to a fixed star and hold fast to its moorings with a bulldog tenacity until the world sees its determination and recognizes its merit.

## NEWS LETTERS.

### St. Louis Items.

The Heman Construction Co., 754 Title Guaranty Bldg., St. Louis, Mo., has a couple of miles of new electric line work in Southern Illinois to sublet. There is some elegant team work on this piece.

Newt Wilcoxen is back in the harness again as manager of the St. Paul office of Clapp, Norstrom & Riley. Contractors when in St. Paul drop in Rooms 1308-9 Pioneer Bldg., and see them.

Mulvill Bros., of Alton, Ill., have three small pieces of work in the neighborhood of Alton and Woodriver, Ill., to sublet.

Keating Bros. report that they have enough work on the Chicago & Illinois Midland R. R. near Auhurn, Ill., to hold them all winter.

A. W. Nyquist is now with the DuPont Powder Co. at Ashburn, Mo.

Chas. Nagel is taking life easy at LaGrange, Mo. Nagel is getting out a little rock for shore protection work.

The Missouri Valley Construction Co. has increased forces on its rip-rap work on the east side of the river here.

J. E. Lyman, a first class all around railroad superintendent, is here idle at present.

D. A. McLaughlin left here for Worthington, Ohio, where he is going to boss a job of track laying and steam shovel work.

P. J. Murphy, Moberly, Mo., has 15,000 yd. of betterment, 5,000 yd. of which is good station work, to let on the Wahash R. R. Free transportation for labor and outfits.

MeArthur Bros. Co., 120 Broadway, New York City, has 600,000 yd. of steam shovel work and 7,500 yd. of concrete work on eight miles new line for Pennsylvania R. R., 40 miles west of Pittsburgh, Pa., to sublet.

Roach & Stansell's bid of 15.38 ct. was the lowest received here by the Mississippi River Commission Dec. 4, 1916, for constructing 100.00 cu. yd. of earth work in the East Cape Girardeau and Clear Creek Drainage District, Ill.

D. O. Sullivan came in from McClure, Ill., to attend the East Cape Girardeau Government levee letting. This levee is being built right alongside of his farm and Sullivan was very anxious to get this piece of work, but bid a little too high.

## PERSONALS.

John L. Howard has been appointed assistant to the chief engineer of waterworks of the Metropolitan Water and Sewerage Board, Boston, Mass. Mr. Howard until recently has been assistant engineer to the directors of the Port of Boston.

Pearl A. Little of Frederick, Okla., county engineer of Tillman County, has been appointed county manager. The duties of his position include constructing roads and bridges, buying all material and keeping a system of accounts.

Emil A. Bechstein, for a number of years general manager of the Sandusky, O., Gas & Electric Co., has been elected second vice president of that company, succeeding P. A. Staples. Mr. Bechstein is also president of the Ohio Electric Light Ass'n.

J. P. Clarke and Thos. B. Powell have organized the firm of Powell & Clarke and will engage in a civil and mining engineering business with office at Ashland, Ky. Mr. Clarke until recently was with the city engineers' department of Richard, Va., and Mr. Powell was with the engineering department of the Chesapeake & Ohio Ry.

P. A. Staples, formerly vice-president and general manager of the New Jersey Power & Light Co., Dover, N. J., and second vice president of the Sandusky Gas & Electric Co., has been elected vice president and general manager of the Binghamton, N. Y., Light, Heat & Power Co., succeeding S. H. Dailey, who has been made general manager of the public utilities operating in Lexington, Ky.

## INDUSTRIAL NOTES.

The W. W. Williams Co. has succeeded to the business of W. W. Williams, Brunson Bldg., Columbus, O., representing the Koehring Machine Co., and Sterling Motor Truck.

The Catholic Bishop of Chicago has authorized Raymond piles in the foundation of the Preparatory Seminary, Chicago, Ill. A hotel building for Wheelock & Shank, Chicago, Ill., will be supported on Raymond concrete piles.

D. L. Sacks, who for the past five years has been associated with the St. Louis branch of H. W. Johns-Manville Co., has now taken charge of the advertising department of the Walter A. Zelnicker Supply Co., St. Louis, Mo.

Among the contracts recently awarded the Raymond Concrete Pile Co. of New York and Chicago are the following: Raymond concrete piles in the foundation of new round house for the New York, New Haven & Hartford R. R., South Boston, Mass. Raymond pile foundation for a new building for the Providence Telephone Co., Providence, R. I. Concrete piles under the Kaufman Warehouse, Pittsburgh, Pa., for the Investment Land Co. Raymond piles in the foundation of a new building for the Oakes Mfg. Co., at Steinway, L. I. John A. Roebling & Sons Co. has ordered Raymond piles for the foundation of an extension to their wire mill at Roebling, N. J. Concrete piles in the foundation of a garage for the Bush Terminal Co., South Brooklyn, N. Y. Piling for the Afton Development Co., at Afton, N. Y. Quartermen's houses, concrete piles, special concrete construction, and water intake for the Bethlehem Steel Co., Sparrows Point, Md.

## Buildings and Structural Issue of

# Engineering and Contracting

Halbert P. Gillette, *President and Editor*

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### A BIG TOAD IN A LITTLE PUDDLE OR A TADPOLE IN A LAKE—WHICH?

To the young man entering any profession or business there is sure to come this question: Shall I seek a position of small responsibility in a large organization, or is it preferable to join a small organization where my responsibility is likely to be greater?

We note that in his presidential address before the Institution of Civil Engineers, Sir Maurice Fitzmaurice advises young engineers to seek positions "on a large work with a small salary," in preference to a resident engineership "on a small, unimportant work at a higher salary." He gives as his main reasons three advantages that come from being one of a large organization: First, the opportunity of seeing "a little of almost every class of work." Second, the daily intercourse with many other engineers, which, through emulation, spurs ambition. Third, the "engineering atmosphere, which may have a real influence on the life of a young engineer."

This is a fairly complete enumeration of the advantages of being one of many engineering assistants on a large job, but perhaps the most important one is not named by Sir Fitzmaurice. The opportunity of becoming acquainted with the methods of the chief engineer and his right-hand men, and, to some extent, with these men themselves, is itself often an educational influence of the greatest importance.

On the other hand, there are certain marked advantages that come from being "a big toad in a small puddle," namely: First, self-reliance is developed at a more rapid rate. Second, executive ability is more apt to be called forth. Third, concentration of effort in a narrow field is more apt to develop good habits of work than seeing a great variety of work done by other men.

The writer passed his first four years of post-graduate experience on small jobs, where his responsibilities were large. Then followed two years of work as a smaller cog in a very large engineering work. Looking back upon the training secured in these two classes of work, the writer would place them both on about an equal plane, and neither one to be given up for more of the other kind. In short, he believes that it is highly beneficial, particularly right after four years of engineering study, for a young engineer to secure a responsible position on a small construction job. Self-reliance is thus developed, and, even if it becomes exaggerated into "swell headedness," self-reliance is preferable to knowledge gained from seeing other men do things.

A debate on the relative advantages of big and little works as places for gaining experience might have no end, so long as statistics are not produced. The editor knows many highly successful men who have started early in life as "big toads, etc." Highly successful men of his acquaintance who have begun in this manner outnumber those who have started as small cogs in a big machine.

The owner of one of the largest department stores in America recently said: "It is a rather curious fact that most of the heads of my different departments started in small town stores."

Wouldn't it be not only interesting but very instructive to gather statistics about highly successful men of all classes, with a view to ascertaining whether or not it is preferable for the average man to start in a responsible position on a small enterprise or as a flyspeck on a big one?

### "TO DO ANYTHING REALLY WELL, THERE'S ONLY ONE WAY—"

A recent advertisement in a Cleveland newspaper begins with the words above quoted, and then it adds:

"Admit you don't know and ask questions.
"Pattern after those who have succeeded.
"Read everything written on the subject.
"Get everybody's ideas.
"Know all about it."

That is the advice of the People's Savings Bank, and it offers as a reason why the reader should ask them for a book on "Home Economy" by "a woman who knows."

Among the five sentences of advice not one is new, and every one is self-evidently ideal. Yet few people habitually act upon such advice. Take the matter of reading what has been written on the subject—any subject that a man is really interested in—and note how seldom the attempt is made to read even the most important parts of its literature. To read "everything" on certain topics is, perhaps, physically impossible, but to read everything of known worth is often a relatively easy task. In straightaway text, involving no study of formulas or the like, a man can read a page a minute where there are about 300 words to the page. Hence in a day of seven hours steady reading, a book of 400 pages can be absorbed. If the subject matter is difficult or if it is new in its import, a second or even a third reading may be necessary before a complete grasp of it is had. But even so, how small is the time and the effort involved in thus making the experiences of other men your own.

If reading on scientific subjects were regarded as a process of acquiring experience rather than as a self-inflicted duty, we doubt not that vastly more time would be spent in reading books and periodicals; for what one of us is there who does not take pride in his experience?

What is experience? Knowledge gained as to the action of the various energy-groups that constitute the universe. It is true that the knowledge that a man acquires at first hand—by direct contact with other men and with nature—is the sort of experience most apt to dive deeper than the iris of the eye or the tympanum of the ear. But that is absolutely the only reason why first hand knowledge is apt to be better than that secured through the channels of human communication. Of course, there is usually this defect in the written or spoken word, namely, that it does not convey all the facts and conditions that were observed by the writer or speaker. That defect, however, should not serve to deter us from a study of the recorded experience of others, with a view to making their experience ours, in so far as we can ascertain and absorb their experience.

It is the province of an author to omit no essential part of the experience picture that he paints with language, drawings and other symbols of energy-groups. The true skill of an author depends on the completeness with which he attains this object.

We have, during the last ten years, noted a very marked improvement in the completeness of the average paper read before an engineering society. The experience pictures are more faithfully and fully painted. The same holds as to the articles in the best technical papers. There still persists, however, a tendency to describe facts that have no evident bearing upon the usable part of the experience that is being recorded. Thus, it detracts, rather than adds to the clarity of the picture, to tell how many yards of concrete were placed each and every day of the month or year. The average, the maximum and the minimum day's performance should be given, and usually that is enough. If there is departure from such a rule, it should be to illustrate the effect of some stated cause. For example, the output in freezing weather may fall below the average for the year. This certainly should be shown.

Recorded experience is admittedly defective in many cases, but we are striving to reduce the defects and we are succeeding in our efforts. Success in this effort is proven by the fact that books and papers on engineering matter are finding more readers every year.

"Get everybody's ideas." And when you do, you will have become aged in experience, even while you are still young. Who was it that said: "We speak of the ancients as the experienced wise men. Yet it is we moderns who have the experience and wisdom of all past time, and our own added thereto."

## TWO OF THE LUTEN PATENTS ON REINFORCED CONCRETE DECLARED INVALID.

Suits for infringement of reinforced concrete patents less than 10 years' old have not been resulting favorably for many inventors. Among the latest of these suits was one in Ohio for infringement of patents Nos. 853,203 and 1,070,903, by Daniel B. Luten, which was decided against the inventor.

Judge Slater of the U. S. District Court, ruled that there was only "mechanical skill" and absence of invention in these two patents. Patent No. 853,203 relates to spandrel-wall arch in which the reinforcement of the spandrel and the arch rib is continuous, as to which Judge Slater said that the union of two rods into one "does not rise to the dignity of invention." Monier's French patent No. 77,165 (1873), Hyatt's English patent No. 2,968 (1877) and Brannon's English patent No. 2,703 (1871) were cited as anticipations.

Securing patents on improvements in the design of engineering structures is relatively easy, but defending them successfully against attack has become exceedingly difficult.

## WHAT IS THE NATURAL LIFE OF AN IRON BRIDGE?

Iron and steel railway bridges in this country have had an average life of about 25 years. This short life has been due, however, not to deterioration by rusting, but to inadequate strength. Increasing weight of rolling stock, therefore, has been the cause of the short life of steel railway bridges.

An iron toll-bridge that spanned the Mississippi at Keokuk has recently been removed after 46 years of service. Physically it was still in good condition, and might have lasted half a century longer. It had been repainted only five times during its entire life, which makes its excellent condition even more remarkable.

The bridge carried a single-track railway floor and a narrow highway floor. It consisted of a drawspan of 380 ft. and two 256-ft. and eight 165-ft. fixed spans of a modified Whipple type. The boiler and machinery that operated the drawspan were still in service but about ready for the scrap heap. The masonry piers would have required only pointing and minor repairs. None of the chord pins had lost, through rust or wear, more than 2 per cent of their cross-section.

Records such as this are not numerous in this country, mainly because the functional or economic life of the bridges usually ends long before the end of the natural life is in sight. Probably the natural life of a modern steel bridge would considerable exceed a century, if kept well painted and not subject to acid fumes from locomotives or other similar agencies of destruction.

## BONUSES AND PROFIT SHARING AT CHRISTMAS.

The custom of profit sharing is growing. Undoubtedly this year will come to a close with vastly more "Christmas bonuses" for American employes than in any previous year.

In many instances companies distribute bonuses in the form of stock in the company itself. More often the bonus is in cash, its individual amount depending on the length of past service and the size of the salary of the employe. Thus the Blaw Steel Construction Co. has just given each of its monthly salaried employes (except those whose salaries exceed $4,000) a bonus whose amount was determined thus:

| | | |
|---|---|---|
| Length of service.............. | ½ to 2 years | 5 per cent |
| Length of service.............. | 2 to 3 years | 6 per cent |
| Length of service.............. | 3 or more | 7 per cent |

An employe whose annual salary is $1,000 would thus receive a bonus of $50 to $70, depending on the length of service with that company. It should be added that the Blaw Company has also a profit sharing plan, and that those who participate in it do not, in addition, receive a bonus of 5 to 7 per cent. of their salaries.

In many a municipality the salaries of teachers, engineers and other public servants have been woefully inadequate, even before the war sent living costs skyward. But we have yet to hear of one city that has put into the Christmas stocking of a single employe a bonus of as much as 1 per cent. on his year's income. Is it not worthy of more than passing consideration that the "warm-hearted, generous American public" is, as a public, about 40 degrees below zero in its atmosphere of considerateness at Christmas time, whereas "the cold-blooded, calculating business man" is often a real Santa Claus when he finds that his year's efforts have netted a substantial profit? Think it over, those of you who are given to look to government for the cure-all of social ills.

## SIX LARGE CITIES TALKING THE "CITY MANAGER PLAN."

Now that nearly a hundred of our smaller cities have "city managers"—usually civil engineers—directing the business of the city, some of the largest municipalities are beginning seriously to consider abandoning the present form of "representative government" in favor of government by an executive selected by "directors." In Philadelphia, Pittsburgh, Cincinnati, Cleveland, Chicago, Kansas City and Minneapolis, certain daily papers are advocating the change.

In Clevand, for example, a nominating committee appointed by 50 civic organizations has just met to consider the selection of 15 men to investigate the city manager plan. Among the members of this committee is Dr. Charles S. Howe, president of the Case School of Applied Science.

The Cleveland Press urges a change in the city charter to enable the city to adopt the modern method of managing a city like a stock company. The Press says:

"The conduct of city affairs should be in the hands of a thoroughly trained and well tried city manager, chosen not for a definite period, but to hold office as long as he does his work well."

At last the American public begins to see that periodic selection of councilmen and mayors by election is a poor way of getting good municipal government. Imagine a railway system operated under the direction of men selected anew every two to four years, by popular vote! The glib-speaker, the sweet-smiler, the hearty hand-gripper, would then have a better chance of being president of the railway than the man who had spent all his life studying and practicing railway construction and operation.

The fact is that our entire system of "representative government," in which representation comes solely through elections, is an uneconomic system, and is destined shortly to be changed. The change has already started in our smaller cities and is about to spread to the larger ones. Then it will spread to counties and states, and finally the Federal government itself will be reorganized completely after the same general fashion.

## WHY CEMENT STORED DURING WINTER MAY HARDEN.

The editor once lost several hundred barrels of cement that he was compelled to store during the winter. The cement was placed in a barn, where no rain could reach it, and was left there about four months. When it was taken out in the spring most of it was almost as hard as rock. The moisture in the air had been sufficient to cause the cement to set.

The action is apparently this: On a relatively warm day the per cent of moisture in the air may be high. Then a cold night causes the moisture to condense on the cement, like a dew. Obviously if this process is repeated enough times, the cement will be quite as effectively watered as if it had been rained upon.

The proper protection against such action is obviously heat. The store-room should be kept warm enough to prevent the dew points being reached at any time. Salamanders will serve where store-room is small, steam pipes where it is large.

## TYPES OF BRIDGES FOR HIGHWAY TRAFFIC.

The following types of bridges for highway traffic are given preference by the Illinois State Highway Department:

### Concrete Bridges.

**Culverts**—For culverts requiring an area of water-way of 12 sq. ft. or less: plain or reinforced concrete arches or circular culverts, reinforced concrete boxes, reinforced concrete pipe or standard cast iron water pipe.

**Small Bridges**—For culverts having a water-way of more than 12 sq. ft., and for bridges having spans up to 30 ft.: reinforced concrete slabs, plain or reinforced concrete arches.

**Bridges**—For bridges having spans of 30 ft. to 65 ft.: reinforced concrete through or deck girders, plain or reinforced concrete arches. For bridges having spans greater than 65 ft.: plain or reinforced concrete arches.

**Arches**—In general plans for plain or reinforced concrete arches will not be approved unless founded on solid rock or unusually firm hardpan, except for paved culverts and very small paved bridges.

### Steel Bridges.

In general, plans for steel bridges will not be approved except for structures spanning drainage ditches, navigable channels, and for locations where the cost of concrete structures would be prohibitive.

**Bridges over Drainage Ditches**—For bridges spanning drainage ditches where it is anticipated that it will be necessary to remove the bridge superstructure periodically to permit the passage of a dredge, pin or bolted field connections shall be used.

**Types for Various Spans**—For bridges having spans of 12 ft. to 45 ft.: steel I beams.

For bridges having spans of 30 ft. to 100 ft.: plate girders or riveted pony trusses.

For bridges having spans 90 ft. to 160 ft.: riveted trusses with parallel chords.

For bridges having spans of 160 ft or more: riveted or pin connected trusses with parallel or inclined upper chords.

## NATIONAL SOCIETY OF STRUCTURAL ENGINEERS.

To the Editor: I can not otherwise than be interested in such an organization, but it seems that there are so many organizations now and that most of us who are trying to earn a living do not have time or means to live up to our obligations to those of which we already are a member.

It seems that the older engineering societies are not progressive in regard to the attention which they think necessary to the requirements of the modern every-day struggling engineer. It seems that they consider it beneath their dignity to adopt any measures which pertain to the economic side of engineering as applied to the engineer himself and his means of livelihood.

The writer has heard these subjects brought up and discussed at some of the meetings of the older societies and has observed that the engineers who had reached the high ranks in the profession in most cases believe that the honor attached to membership was a sufficient return to the engineer.

This is a long, long story and I have not the time to go into details. The Western Society has recently made a step forward in these matters and if it were not for the fear of "Mrs. Grundy" I believe they would go still further. With all due respect to the previous secretary who was a very fine gentleman, in the writer's opinion, the new secretary has, I believe, more advanced ideas in regard to what the society should do to assist the engineer who needs assistance.

I do not know if it is practicable to organize another society or not. I wish you much success in your endeavor. Certainly there should be some movement that would furnish the engineer protection against the encroachments of those who would exploit the profession and secure legislation that would prevent the engineer from asserting himself for his own advantage.

Yours truly,
Francis H. Wright.

415 American Trust Bldg.
Cedar Rapids, Ia.

## THE DESIGN OF STEEL STACKS.

To the Editor: I have read with interest the letter by Mr. H. M. White of the Dominion Bridge Co. of Montreal, in the issue of Nov. 22, regarding the article on "The Design of Steel Stacks" printed Oct. 25.

Mr. White's statement that the designing curves given in the article are correct and convenient for use justifies their introduction and use, and really expresses the main purpose in presenting the problem.

I acknowledge the two numerical errors pointed out. These, while inexcusable, having occurred in the hasty preparation of the original paper, would have been corrected had I known that the article was to be reprinted. These do not, however, occur in any of the preferred solutions. In each case where more than one analysis was given, the one given first was the preferred solution and the one used in plotting the curves.

It is interesting to note the lack of consistency on the part of the critic. He closes his letter by stating that nothing new was given in the original paper, yet spends a large part of his space in ridiculing the secondary solutions as though they were being given for the first time, while as a matter of fact these assumptions criticized have long been used by other designers.

It may be well to have still another solution proposed for anchor bolts, though no evidence was given in the letter that would prove the critic's assumptions any better for working designs than the proposed solution No. 1. His new solution give values of approximately 70 per cent of the values obtained by solution No. 1. The designer must decide whether he wishes to assume this risk. A study of recent designs would indicate that most engineers are not willing to do so.

The critic is in error in his statement regarding the comparison of the three proposed anchor bolt solutions. The comparison given in the original paper applied only to the specific problem of 12 bolts and not to the general case, as he would have the reader infer.

The apparent error pointed out in Equation 44 for stress in shell at connection to base plate is another case of trimming down the design. The proposed Equation 44a, for the common case where B equals 1½ D, gives a stress per lineal inch at the base plate only 44 per cent of the stress given by Equation 44 of the writer's. Again the designer must choose. For the case of a tapering stack Equation 44a might result in some saving in material.

Therefore, while the critic has pointed out the fallacies of the usual assumptions, which are admitted by all, he has failed to show that the preferred solutions shown on the designing diagrams represent unsafe practice.

Very truly yours,
W. A. Hitchcock,
Assistant Professor of Civil Engineering,
University of Wyoming,
Laramie, Wyo.

Dec. 6, 1916.

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## BETTER AND MORE ECONOMICAL MANAGEMENT OF COUNTY ROAD AND BRIDGE AFFAIRS.

To the Editor:

I have before me a copy of your Quarterly Magazine on Planning and Management under date of Nov. 29, and heartily endorse your movement for better and more economical conditions in county road and bridge affairs.

I find in Allen County, Ohio, that the average county commissioner and township trustee is a respectable, law-abiding citizen, who wants to get along and be respected by everyone, and, in order to do this he is obliged to cater to some certain political and business influence for their support, and they dictate largely the policy to be pursued.

The county surveyor has been used as a mere clerk who is expected to approve all bills that come before him without question. You will find enclosed one of my campaign maps that explains my contention and defeated me for reelection this fall.

I believe each township should have a representative on a county board of directors, this board to meet weekly, semi monthly, or each month, with the county engineer, who shall be the service director for the entire county and outline a definite road and bridge program and have general charge or act as agent, for the county board of directors and receive bids, award contracts and supervise all construction work and select competent force to carry out the plans effectively.

We have three county commissioners and 36 township trustees in Allen County, requiring an expenditure for salaries of about $10,500 per year. If this number be reduced from 39 to 12 at $5 for one day each week, Allen County could make a saving of about $7,500 per year with better results.

Yours truly,
W. R. Toy,
County Highway Superintendent.
Lima, Ohio.
Dec. 4, 1916.

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The final blast "holing" through the headings of the south tube of the Old Slip-Clark Street tunnel beneath the East River at New York City was "fired" on Dec. 19. The north headings were connected on Nov. 28. The Old Slip-Clark Street tunnel which is being constructed by the Public Service Commission for the First District is for operation by the Interborough as a part of the Park Place, Beekman and William Street branch of the Seventh Avenue subway and will connect the Seventh Avenue line with the First Subway in Brooklyn. The north headings met on November 28 almost underneath the center of the river with a deviation of less than an inch from true lines and the meeting of the south headings was even more accurate. The tunnel is being built at the contract price of $6,469,916.25. It is 17 ft. 6 in. in diameter and at its greatest depth is 88 feet below the surface of the river.

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## DESIGN AND CONSTRUCTION FEATURES OF A REINFORCED CONCRETE SLURRY ELEVATOR.

Contributed by D. C. Findlay, Chief Engineer, Oregon Portland Cement Co.

On June 1, the Oregon Portland Cement Co. placed in operation a new 1,200-bbl. cement mill at Oswego, Ore., using the wet process, which is noteworthy for several reasons, chief of which is its cleanliness and freedom from dust nuisance.

This article deals with a novel method adapted to handle the "slurry" feed for the rotary kiln. The "slurry" is ground with a Smidth Kominuter as a preliminary grinder and finished with two No. 85 Type E Cylpeb tubemills which reduce the fineness to 90 per cent on the 100 sieve. It is then discharged by means of a 12-in. screw conveyor into either of three correcting basins, from which it is drawn to a large mixing basin holding about 1,000 bbls.

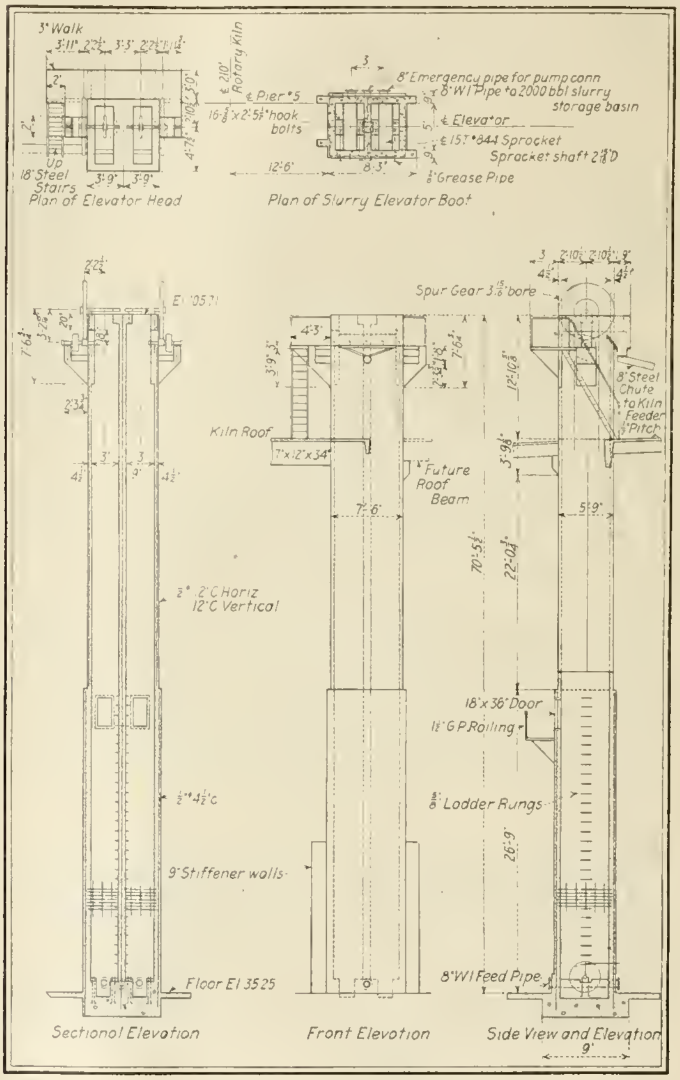


Fig. 1—Sectional Elevation, Front Elevation and Side Elevation of Reinforced Concrete Slurry Elevator.

An Ingersoll-Rand air lift pumping system then pumps it over to a 2,000-bbl. reinforced concrete storage basin which is 26 ft. deep, and is built between the 4th and 5th piers of the 210-ft. rotary kiln, and directly under the kiln. This storage basin has its bottom 16 ft. below floor level and is mechanically agitated by three vertical agitators.

The almost universal practice previously has been to pump the "slurry" from the storage basin to the kiln feeder, using three plunger vertical motor driven pumps. Owing to the nature of the material it is hard to pump, and the wear on piston plungers is great, as is the expense of renewing packing, which must be of the highest grade; also a large quantity of oil is required for lubrication. If the packing is not perfect, the pumps soon become very dirty and the floor covered with semi-liquid slurry.

To overcome this, the writer designed a reinforced concrete continuous bucket elevator casing as shown in Fig. 1, 7 ft. 6 in. by 6 ft. 6 in. outside, and 70 ft. 5½ in. in height. In order that continuous operation might be assured, a center partition divides the elevator into two separate units, so that in case of trouble on one side the other side may be placed into service, and used to feed the kiln; or should a chain break with slurry in the leg, by closing a valve to the storage basin, the other elevator can be used to empty the damaged one for repairs.

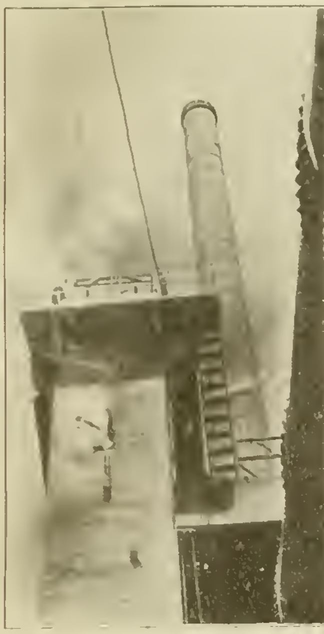


Fig. 2—View Looking Up at Top of Elevator.

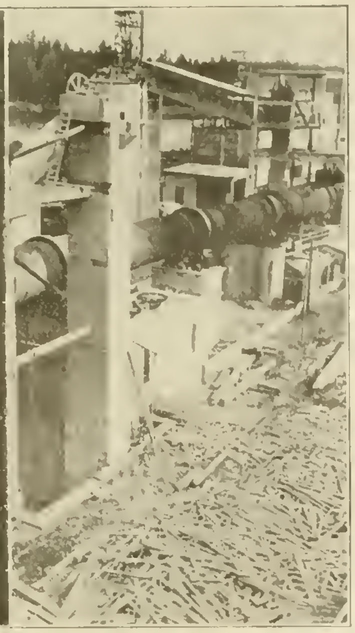


Fig. 3—General View of Elevator and Feed End of Kiln.

It will be noted that the slurry is fed into the bottom of the two elevators, through 8-in. pipes connected each through a gate valve and tee to a common 8-in. pipe, concreted into the bottom of the storage basin. Therefore the slurry stands at the same level in the elevator legs as it does in the basin, and the elevators must stand the bursting pressure of a head of 26 ft. of slurry weighing about 108 lb. per cubic foot, and containing about 40 per cent water.

The walls as built are only 9-in. thick, and are absolutely watertight. No waterproofing solution was used, nor were the walls plastered.

The concrete mixture for the first 31 ft. 9 in. was a 1:1½:2 mixture using screened gravel, and was thoroughly mixed and tamped to fill all voids.

The drawing shows the method of reinforcing. All horizontal bars had hooks turned on the ends fastening around the vertical corner bars, and securely wired at every intersection.

The bottom sprocket and bearings are thus completely submerged. Solid and cast iron bearings were used, being unbabbitted and bored to a fit of only 1/1000 in clearance. Three-eighth-in. compression grease cups connected to pipes cast into the walls are used to force grease into the bearings for lubrication, and to prevent any tendency for slurry to work along the shaft.

No take-ups were used, but the bearing bolts were left up 6½ in. and the bearings blocked up on steel wedges on starting, to allow for lowering same as wear lengthened the chain. These anchor bolts had lock nuts, and were drilled for cotter pins also to prevent the nuts coming loose. As No. 844 Manganese steel chain was used there will be very little wear.

Wrought iron, continuous type V-shaped buckets were bolted to the chain, using K 2 attachments every 2 ft. A 28-in. No. 844 traction wheel is used at the top and the detail of drive is shown in Fig. 1, also the method of widening out the walls to carry the heavy three 15/16-in. bearings. The pinion shaft with pinion and drive pulley is carried with one bearing set in the wall and the other by an outboard bearing on a heavy concrete bracket from the wide walls.

A reinforced concrete slab walkway (see Fig. 2) carried on brackets from the walls enables the operator to get around the elevator head and a set of steep steps leads to the concrete roof over the kiln.

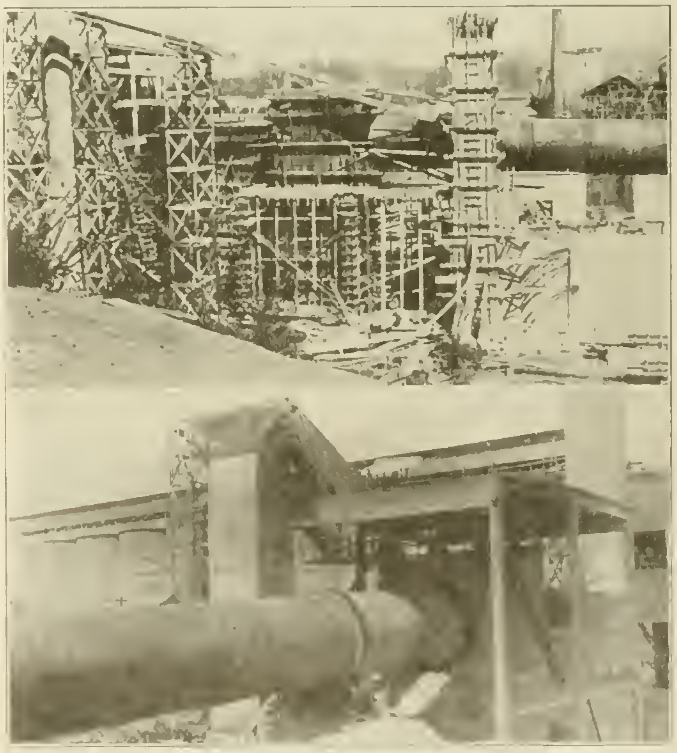
A steel chute is securely bolted to the concrete, from which an 8-in. steel pipe leads to the automatic "Ferris" type slurry feeder which has four buckets on a horizontal shaft driven by a 2-H.P. variable speed motor. These buckets lift out a definite amount of slurry each revolution, and deliver same to the kiln. The overflow goes back to the storage basin to be elevated once more.

An 18-in. x 36-in. door is built into the walls above the level of the slurry, and ⅝-in. ladder rings in the walls give access to the bottom of the elevator boot, also a ladder outside leads down to the gate valve which cuts off the slurry from the basin.

It happened that the elevator came directly where a roof column should be to support the concrete roof, so the roof beams were framed into the walls as shown, and brackets left for attaching the future roof over the second kiln, at which time the elevator will be completely surrounded, and project 12 ft. 10 in. above the roof, unsupported.

The elevator has been in service for three months now with excellent success, and with practically no maintenance. Each elevator is driven by a belt from a countershaft on the kiln housing, and only requires about 5 H.P. to operate.

On account of the various steps in the walls, etc., movable forms were not used, but forms were built up in and about 15-ft. sections and concrete poured, after which the next section was built. The accompanying illustrations show the elevator in various stages of completion. The writer believes there is a great future for the concrete elevator leg, as it combines great strength with great wearing power, where handling abrasive material or where waterproof requirements are needed, and at a price much less than can be built using steel. The writer built his first concrete elevator in 1912 at Tod Inlet, B. C., and has since built six with very gratifying results. The Oregon Portland Cement Co. also have a single leg concrete elevator, 56 ft. high, handling clinker, which is



Upper: Reinforced Concrete Elevator Under Construction. Lower: General View of Concrete Elevator and 210-Ft. Kiln.

a most abrasive material. The design and supervision of construction for the Oregon Portland Cement Co. was in charge of the writer.

## PARTITION OF LOAD IN RIVETED JOINTS.

Theoretical analyses and experiments made by Cyrol Batho, Assistant Professor of Applied Mechanics at McGill University, indicate that a series of equations can be obtained, giving the load carried by each rivet in any form of riveted joint in terms of a quantity K, which if the rivets are in shear depends upon the manner in which work is stored in the rivets; or if they act by frictional hold on the plates, depends upon the work stored in the parts of the plates thus held. The position of the load was worked out theoretically by means of the Principle of the Least Work. The experiments were made upon different forms of joints, having a single line of five rivets on each side of the joint, and loaded in tension. The theoretical and experimental work is described by Prof. Batho in a paper in the November Journal of the Franklin Institute, from which the following is abstracted:

Only the specimen with ½-in. rivets was carried beyond the working load, but the regularity of its action showed that the partition of load obeyed the same laws at all loads up to that causing permanent deformation of the plates or rivets. In every specimen and at all loads the first and fifth rivets took by far the greater part of the total load, the actual proportion decreasing gradually as the load increased. For example, in the specimen with ½-in. rivets, the first and fifth rivets carried 83.5 per cent of the total load at a load of 10,000 lb., and this decreased to 70.0 per cent at a load of 30,000 lb. The latter load corresponds to an average stress of about 12,650 lb. per square inch of actual rivet section, or 15,280 lb. per square inch of nominal rivet section. This would usually be taken as the shearing stress on all the rivets, but actually the end rivets, if, as there seems little doubt, the rivets were in shear and not holding by friction, were each under an average shear stress of 22,150 lb. per square inch, while the third rivet at the same load took only 3.2 per cent, corresponding to an average shear stress of only 2,020 lb. per square inch. Thus in joints having several rows each containing an equal number of rivets and designed in the usual manner, i. e., allowing the average load per square inch of rivet section to be equal to the working stress in shear of the rivet material, the rivets in the end rows must carry stresses far above the allowable working stress.

The above refers to the specimens in which the cover plates were of the correct thickness; i. e., each half as thick as the middle plate. If they are thicker, the first rivet takes an even greater proportion of the load, the proportion increasing with increased thickness. In specimen B, in which the cover plates were of correct thickness, the first and fifth rivets took 88.1 per cent of the load at a load of 16,000 lb. In specimens D, E and F at the same load they carried 86.2 per cent, 89.7 per cent and 78.9 per cent of the total load respectively, but of these the first rivets carried respectively 70.7 per cent, 63.8 per cent and 50 per cent of the total load. Specimen F, in which the middle plate was of varying width, illustrated the action in members riveted to a gusset plate, and it was found that the varying width of plate resulted in a rather more even distribution of stress, the first and fifth revets carrying only 69.7 per cent of the load, as compared with 78.9 per cent when the middle plate was cut down to uniform width.

In all the specimens tested the ratio of width of cover plate to pitch of rivets was the same, ¾. K probably varies as the width of cover plate divided by the pitch of the rivets; thus, with a smaller pitch or wider plates, K would be increased, and the effect of this would be to make the partition of the load rather more uniform. But a large variation of K only causes a comparatively small alteration in the percentage of the load carried by the end rivets. For example, in the specimen A a change of K from 0.485 to 1.3 only altered the load carried by each of these rivets from 40.7 per cent to 35 per cent, and the alteration for a given change becomes less and less as the values of K increase. Thus the effect of change of pitch or breadth of cover is not likely to be very great, except possibly in splices containing a number of rivets in each row. However, further experiments are needed in order that a general law may be found for the value of K. When this is determined it will be possible to predetermine the exact partition of load in any proposed joint, and this will enable the joint to be designed in the most efficient manner. A very good approximation, sufficient for most purposes, may, however, be obtained from the data already given, since the general manner of partition of load is the same for all values of K.

Prof. Batho's summary and conclusions are as follows:

1. It is shown that a riveted joint may be considered as a statically indeterminate structure, and that a series of equations may be obtained for any joint by means of Principle of Least Work, giving the loads carried by each of the rivets in terms of a quantity K, which depends upon the manner in which work is stored in, or by the action of, the rivets.

2. This theory is applied to various types of joints, and the modifying effects of non-uniform distribution of stress in the plates, unequal partition of the load between the two cover plates, and a difference in the modulus of elasticity of the middle plate and the cover plates are also considered.

3. It is shown experimentally that extensometer measurements on the outer surfaces of the cover plates of a riveted joint are sufficient for the determination of the mean stresses in the plates, and that the partition of the load among the rivets may be determined from such measurements. It is also shown that, at any rate after the first few loadings, the distribution of strain in the plates of a joint is not altered by repeated loadings.

4. It appears from 3 that if there is any frictional hold between the plates, it acts only over those portions in the immediate neighborhood of the rivets. All the experiments tend to show that friction does not play an important part, but further experiments are necessary on this point.

5. Experiments made on a number of specimens having a single line of rivets and loaded in tension give results in close agreement with the theoretical considerations. They also show that the longitudinal stresses in a portion of the cover plate between two consecutive rivets are a minimum along the line of rivets, rising to a maximum at the edges of the plates.

6. The experiments show that the value of K for a joint having a given ratio of width of cover plate to rivet pitch and a given number of rivets varies approximately directly as the load and inversely as the area of the rivets. An empirical rule is given for its value in joints similar to the experimental specimens, but a more general rule cannot be given until further experiments have been made. A theoretical estimate is made of the value of K for a rivet acting in shear, and the result is shown to be within the range of the experimental values.

7. Both the experimental results and the theoretical deductions show that: (a) in a double-cover butt joint having a single line of rivets, the two end rivets and the two rivets on each side of the junction of the middle plates take by far the greater part of the load at all loads within that causing permanent deformation of the plates or rivets, the actual proportion decreasing slowly as the load increases; (b) if, in such joints, the total area of cross-section of the cover plates is equal to that of the middle plates, these four rivets take equal loads, but if it is greater the end rivets take greater loads than the others, the difference increasing as the area of the cross-section of the cover plates increases; (c) if two plates of uniform width and equal thickness are connected by a single line of rivets to opposite sides of a gusset plate of uniform width, the first and last rivets take the greater part of the load, but if the gusset plate increases in width from the first to the last rivets, the partition of load is more uniform.

The results already obtained allow the general manner of partition of load in any riveted joint, in which there is no eccentricity of connection, to be estimated, and it is hoped that, when further experiments have given general laws for the value of K, it will be possible to predetermine the exact load that will be carried by each rivet. The practical value of this is obvious.

## CAISSON FOR DEEP WATER PIERS OF PORTLAND BRIDGE.

In constructing the harbor piers in deep water for the $965,000 bridge at Portland, Me., the contractors, the Holbrook, Cabot & Rollins Corp., Boston, Mass., used an interesting type of caisson. The following description of this portion of the work is taken from a paper by Eugene E. Pettee in the December Journal of the Boston Society of Civil Engineers.

A site was selected just east of the bridge in an enclosed position where a launching-way was built consisting of a platform resting on piles and sloping towards the water. On this platform a bed of 3-in. lagging was laid, corresponding in shape to the bottom of the pier (see Fig. 1). On this lagging forms were built and a reinforced concrete box constructed, about 4½ ft. deep, having a projecting flange all around the outside, through which projected hook bolts. (Fig. 2.) On this flange wooden sides of 12x12 hard-pine posts with 4-in. hard-pine planking on the outside were built up about 18 ft. high. The top timbers were connected by means of rods with the hook bolts anchored in the concrete, and tightly screwed up. The whole structure was then carefully calked and finally launched. (Fig. 3.) This caisson floated high out of water and was towed alongside of a large lighter equipped with a concrete plant and was gradually filled with concrete. On this concrete as a bed, forms of the proper size for the pier were erected within the caisson, and filled with concrete. As the load increased, and the caisson gradually sank, the sides were twice extended until the total depth reached about 54 ft.

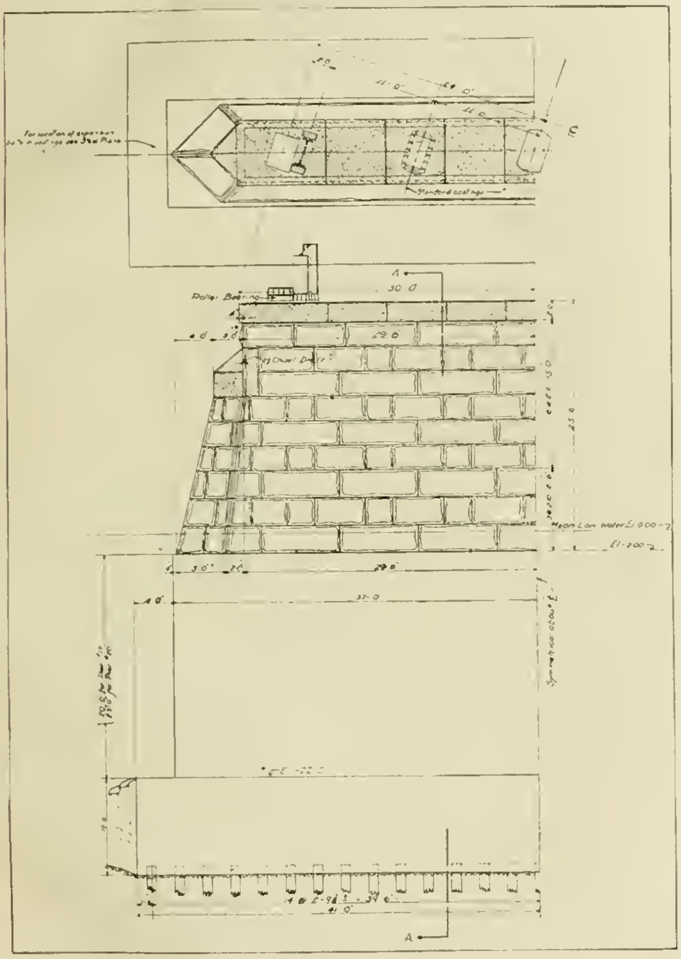


Fig. 1—Foundations and Masonry Piers.

The caisson was then towed to its site which had already been prepared by considerable dredging and by driving piles over the whole area. These piles were cut off quickly by a large circular saw on a vertical shaft carried in the gins of a large pile driver. By means of a level placed on shore, sighting on a white band painted on the vertical shaft carrying the saw, the piles were cut off accurately to grade. The caisson was then filled, until it touched bottom at low tide, when it was very exactly located by means of two transits set up on shore at right angles to each other, and sighting on the two center lines of the caisson. Water was then let into the space between the sides of the caisson and the concrete pier (Fig. 4) until the caisson become so heavy that it would not float again at high water.

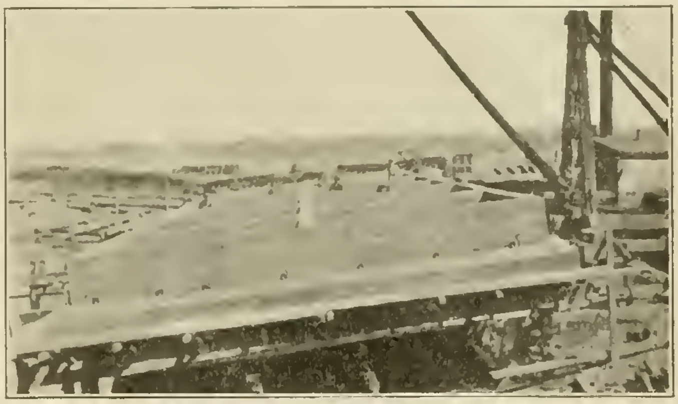


Fig. 2—Caisson on Launching Ways.

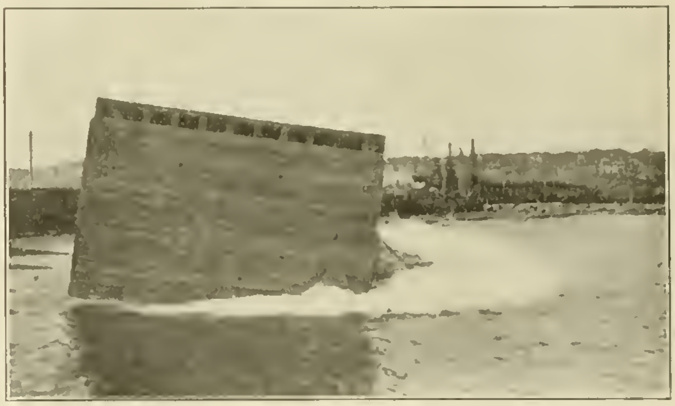


Fig. 3—Launching Caisson.

Then came the work of building up the concrete to elevation —2, where the granite facing began. This facing was carried up well above high water, the concrete core being carried up simultaneously. The rods connected with the hook bolts at the bottom of the caisson were then loosened and the connections unhooked, allowing the sides to float up to the surface. They were then towed away and used on another caisson. This method permitted all concrete work to be cast dry, and also permitted thorough inspection.

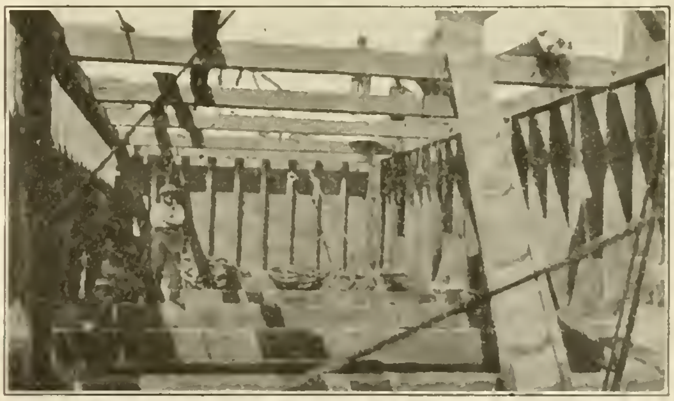


Fig. 4—Sinking Caisson.

## RECOMMENDED SPECIFICATIONS FOR REINFORCED CONCRETE DESIGN.

The Portland Cement Association has issued recently specification for reinforced concrete design. The specifications are based on the regulations in the building code recommended by the National Board of Fire Underwriters and the 1916 report of the Joint Committee on concrete and reinforced concrete. The specifications follow:

**Loads.**—The schedule of superimposed uniform (live) loads per square foot is as follows:

Roof ........................................pounds per square foot
................ floor ............................pounds per square foot
................ floor ............................pounds per square foot
Etc.

The roof slab, together with the roof beams and girders, shall be designed to carry the full live and dead loads. All floor slabs and beams shall be designed to carry the full live and dead loads. All girders under floors where the assumed live load is under 120 lb. per square foot shall be designed to carry all the dead load and 85 per cent of the assumed live load. No deduction for floor loads greater than 120 lb. per square foot.

Every column, post or other vertical support shall be of sufficient strength to bear safely the combined live and dead loads transmitted to it.

The following reductions are permissible when the live loads are under 120 lb. per square foot:

For columns supporting roof: No reduction.

For columns supporting top floor: A reduction of 10 per cent of the live load of the top floor may be made.

For columns supporting each succeeding floor: A reduction of 5 per cent of the live load per floor may be made, but the maximum deduction for any floor shall not exceed 50 per cent. The reductions shall cease when a floor carrying a live load of more than 120 lb. per square foot is reached.

For floors, beams, girders and vertical supports carrying machinery: At least 25 per cent shall be added to the stresses from live loads to provide for effect of impact and vibration.

For sidewalks between the curb and building lines: Live loads shall be taken at 300 lb. per square foot or a concentrated load of 5 tons at any point.

**Materials.**—Cement: The cement shall meet the requirements of the current Standard Specifications for Portland Cement of the American Society for Testing Materials.

Steel: The steel shall meet the requirements of the current Standard Specifications for Reinforcing Steel or the American Society for Testing Materials.

Aggregates and Water: The aggregates and water shall meet the requirements of the current specifications for aggregates and water of the Portland Cement Association.

Broken stone or pebble concrete not reinforced shall be assumed as weighing 144 lb. per square foot, and when reinforced shall be assumed as weighing 150 lb. per cubic foot.

**Stresses.**—Extreme fiber stress in compression for 1: 2: 4 concrete, 650 lb. per square inch. For 1: 1½: 3 concrete, 810 lb. per square inch.

In direct compression, 1: 2: 4 concrete, 450 lb. per square inch. 1: 1½: 3 concrete, 560 lb. per square inch.

Shearing stress in concrete when diagonal tension is not resisted by steel, 40 lb. per square inch for 1: 2: 4 concrete and 50 lb. for 1: 1½: 3 concrete.

Unit shearing stress when web reinforcement is used, 120 lb. per square inch, of which 40 lb. per square inch may be resisted by the concrete.

In proportioning the section of concrete for shearing stress, the effective depth from center of compression area to center of steel area shall be used. In beams of T-section the width of the stem shall be used. In ribbed floors the width of the stem and thickness of flange near supports shall be proportioned for cumulative shear on the span.

Bond stress between concrete and reinforcement, 80 lb. per square inch for plain and deformed bars, based on actual section.

Tensile stress in steel, 16,000 lb. per square inch, for main reinforcement. Tensile stress in stirrup steel, 10,000 lb. per square inch.

Ratio of deformation of steel to 1:2:4 concrete shall be taken at 1:15 and to 1:1½:3 concrete shall be taken as 1:12.

Compressive stress in steel shall be equal to the compressive stress in the concrete multiplied by the ratio of deformation.

In continuous beams and slabs the extreme fibre stress in concrete in compression may be increased 15 per cent adjacent to supports.

Bearing on a concrete surface having a total area of at least twice the area of the loaded portion may be taken at 700 lb. per square inch for 1:2:4 concrete and 875 lb. per square inch for 1:1½:3 concrete, and, generally, at 35 per cent of the ultimate strength of the concrete used, when all other stresses are properly provided for.

**Slabs, Beams and Girders.**—The straight-line method shall be used in designing reinforced concrete.

The span length for beams simply supported, and for all slabs, shall be taken as the distance from center to center of supports, but need not be taken to exceed the clear span plus the over-all depth of beam or slab. For continuous or restrained beams built monolithically into supports, the span length may be taken as the clear distance between faces of supports. Brackets shall not be considered as reducing the clear span in the sense here intended, and the clear span between T-beams is the distance face to face of stems. Maximum negative moments are to be considered as existing at the end of the span as here defined.

The bending moments of girders, beams and slabs due to uniformly distributed loads shall be taken as not less than:

1/8 WL, at center when simply supported.

1/9 WL, over central support; and 1/10 WL, near the middle of the span when continuous for two spans only.

1/10 WL, over first continuous support; and 1/10 WL, near middle of end spans when supported at one end and continuous at the other end for more than two spans.

1/12 WL, at center and intermediate supports when continuous over more than two supports.

The simply supported ends of spans shall be reinforced for a negative moment of not less than 1/16 WL.

W = total distributed dead and live loads.
L = length of span.

Floor slabs having supports extending along the four sides shall be designed and reinforced as continuous over the supports. For uniformly distributed dead and live loads the per cent of load carried on the transverse span shall be found by subtracting 0.5 from the quotient obtained by dividing the length by the breadth. The remainder of the load shall be carried on the longitudinal span. If the length of the slab exceeds 1.5 times its width the entire load shall be carried on the transverse span. Using the values thus obtained, each set of reinforcement is to be calculated in the same manner as slabs having supports on two supports only, using correct depths to center of steel. The amount of reinforcement thus determined per foot of width applies only to the middle half of the slab and one half of this amount per foot of width may be used in each end quarter of the slab. The probable distribution of the loads from two-way reinforced slabs to supporting beams or girders shall be ascertained, and the moments in the beams or girders calculated accordingly.

The bending moments for slabs or beams with spans of unusual length or due to other than uniformly distributed loads shall be more exactly computed according to accepted theory.

In continuous slabs, beams or girders, full provision shall be made for the negative bending moments over the supports by placing sufficient negative reinforcement near the top of the members to resist the stress. This reinforcement shall pass beyond the point of contra-flexure in beams or girders and be anchored in the compression concrete of the member a sufficient distance to develop the full strength of the steel through bond stress. The critical section of continuous construction is over the support.

Where adequate bond is provided at junction between slab and beam, and the two are cast at the same time as a unit, the slab may be considered as an integral part of the beam, provided its effective width[1] shall not exceed one-fourth of the span length of the beam, nor be greater than six times the thickness of the slab on either side of the stem.

In beams with T-sections the width of the stem only shall be used in calculating longitudinal shear and diagonal tension. An effective bond shall be provided at the junction of the beam and slab when the principal slab reinforcement is parallel to the beam, by the use of transverse reinforcement extending over the beam and well into the slab.

In the design of T-beams acting as continuous beams, sufficient compression area shall be provided on the under side at the support, either by the use of properly designed brackets or by embedding additional compression steel in the concrete extending to the point of inflection.

The minimum thickness of concrete floor slabs shall be 4 in., and of roof slabs 3½ in.

Cement or concrete floor finish shall not be considered in calculating the strength of floor members unless it be laid at the same time they are cast.

The design of composite floors consisting of rows of concrete tile or hard-burned terra cotta tile, gypsum blocks, sheet steel, or other approved fire resisting material, separated by ribs, or beams of reinforced stone concrete, shall conform to all the provisions of these specifications so far as they are applicable. Not less than 2 bars shall be used in each rib with a minimum space between bars of 1 in. The width of ribs shall be 2 in. plus the widths of the bars plus the spaces between the bars but the minimum width of rib shall be 4-in.

The tile or blocks shall be regarded only as fillers, and shall not be considered in the design except as a dead load.

If designed as a T-beam, the slab portion above the fillers shall have a thickness of at least one-fifth the depth from the top surface to the center of the steel and not less than 1½ in., and shall consist of the same mixture used for the ribs, and shall be cast at the same time. Under these conditions it may be considered in the design of the ribs.

Tile or block fillers shall be laid with Portland cement mortar joints, and shall be thoroughly wet before the concrete is poured.

The protection for steel bars in the bottom of ribs shall be the same as for other beams.

To resist expansion and shrinkage stresses, reinforcement bars not less than ½ in. diameter shall be placed in the concrete at right angles to the ribs and above the fillers, at intervals not exceeding 30 inches.

Steel reinforcement shall have a minimum protection of concrete on all sides as follows:

In columns and girders, 2 in.; in beams and walls, 1½ in.; and in floor slabs, 1 in.

The steel in footings for walls and columns shall have a minimum protection of 1 in. of concrete.

All reinforcement shall be accurately located and mechanically secured against displacement during the placing of the concrete. Reinforcement bars for slabs shall not be spaced farther apart than two and one-half times the thickness of the slab. The spacing of parallel bars in beams shall be not less than two diameters from center to center, nor less than 1 inch. The clear spacing between two parallel layers of bars shall be not less than 1 in. In restrained or cantilever construction reinforcement shall extend beyond the supports into adjacent construction for full and effective anchorage, except that when this is not practicable, anchorage shall be obtained by other means acceptable to the (Engineer or Architect).

Special reinforcement shall be provided to resist concentrated loads.

Slabs reinforced in one direction only shall have shrinkage rods not less than ¼ in. in diameter placed above, and crossing the reinforcement and spaced not over 2 ft. apart.

All reinforcement shall be assembled well in advance of the placing of the concrete, and shall be inspected and approved by the (Engineer or Architect) before concrete is deposited.

Splices in reinforcing bars shall be designed to transfer the calculated stress at the joint either by bond and shear through the concrete or in vertical supports by bearing between the steel. Splices at points of maximum stress shall be avoided where possible. Lap splices of bars shall be of sufficient length to develop the required stress in the joint without exceeding the bond stress permitted, and the lapped portions shall be separated by a space not less than their thickness or a minimum of 1 in.

Members of web reinforcement in beams shall be designed for diagonal tensile stresses, using the calculated vertical shearing stress as a measure of these tensile stresses. The longitudinal spacing of vertical stirrups shall not exceed one half the depth of beam and that of inclined members shall not exceed three fourths of the depth of beam. It may be assumed that all of the external vertical shear in excess of the amount heretofore specified as allowable for concrete is provided for by the steel in vertical or inclined web members and bent up bars.

Web members, such as stirrups, when not rigidly attached to the longitudinal steel at both top and bottom, shall be carried around and bent over the longitudinal members or otherwise sufficiently anchored in the compression concrete to develop the tensile stresses existing in them. Web members shall be rigidly attached to the longitudinal steel on the tension side. Stirrups at the ends of continuous girders shall be inverted with the free ends anchored in the compression concrete at the bottom of the beam. The length of stirrups or diagonals embedded in compression concrete shall be sufficient to develop their entire tensile stresses by adhesion.

**Columns.**—The length of columns shall be taken as the maximum unsupported length.

The unsupported length of columns shall not exceed 15 times the effective diameter or least effective thickness when longitudinally reinforced nor 10 times the effective diameter for hooped columns, and in no case shall the effective diameter or least effective thickness be less than 9 in., measured within the ties or hooping from out to out of the longitudinal reinforcement. The length shall include any corbel or knee brace attached to the column. The effective diameter of columns supporting girdless floors shall be not less than one twelfth the least panel dimension of panels supported by any column.

Bending stresses in columns due to eccentric loads shall be provided for by increasing the section of concrete or steel so that the total unit stress shall not exceed the allowable working stress in flexure.

Suitable steel base plates or castings shall be provided at the bottom of columns to distribute the loads over the footings, and the vertical reinforcement bars shall bear squarely on these plates or the reinforcing bars shall be carried down into an enlarged footing to distribute the load through bond stress.

In columns where necessary to splice vertical bars having areas in excess of 1¼ sq. in., it shall be done by cutting the bars squarely at the ends and enclosing them in a close-fitting pipe sleeve, or uniting them by a threaded splice or other mechanical connection that will transfer the load from one to the other without stressing the adjoining concrete excessively. The middle point of such splices shall be within 1 ft. above the floor level. Splices in column hooping where necessary shall be sufficient to develop the full strength of the hooping.

All interior columns shall be round. When interior columns other than round are used for architectural effect, the corners shall be made of plaster on metal lath built around the columns after they are fully set.

Longitudinally reinforced columns shall have not less than 4 vertical bars or rods secured against lateral displacement by steel ties placed not farther apart than 16 diameters of the vertical bars or rods, nor more than 12 in. The area of the certical reinforcement shall be not less than 1 per cent nor more than 4 per cent, calculated upon the effective area of the column, which is the area within the reinforcement. No vertical bars shall have a diameter or least dimension less than ⅝ in. and steel ties shall be not less than ¼ in. in diameter or least dimension.

Hooped columns shall be reinforced with vertical steel with an area of not less than 1 per cent and not more than 4 per cent, calculated upon the effective area of the column. The vertical bars or rods shall be spaced not farther apart than one-eighth the circumference nor more than 8 in., and be secured to the hooping. The reinforcement, in the form of hoops or spirals, shall be not less than 1 per cent (that is, a volume of steel equal to the required per cent of the volume of concrete within the hoops or spirals for a unit length of column), with a clear spacing not greater than one-sixth the effective diameter, and preferably not greater than one-tenth the effective diameter, nor more than 2½ in. For hooped columns reinforced as herein specified, the unit concrete stresses may be 700 lb. per square inch for 1:2:4: concrete and 870 lb. per square inch for 1:1½:3: concrete.

The load which may be carried by any column shall be determined by the following formula:

$$P = f_c\ (A_c + nA_s).$$

in which:

$P$ = total load in pounds.
$f_c$ = allowable compressive fiber stress in pounds per square inch on the concrete.
$A_c$ = effective area of concrete in square inches.
$n$ = ratio of deformation.
$A_s$ = area of vertical steel in square inches.

Axial compression in structural steel columns thoroughly encased in concrete having a minimum thickness of 4 in. and reinforced with not less than 1 per cent of hooping steel (that is, a volume of steel equal to 1 per cent of the volume of concrete within the hoops), equally divided between vertical reinforcement and spirals or hoops spaced not more than 12 in. apart, may be taken at 16,000 lb. per square inch on the net section of the structural steel, no allowance being made for the concrete casing. The spirals or hoops shall be placed not nearer than 1 in. from surface of the concrete. The ratio of length to least radius of gyration of the structural steel section shall not exceed 120.

Walls.—Exterior and interior bearing and non-bearing walls of reinforced concrete shall be securely anchored to all intersecting walls, columns and floors, and the allowable compressive stress shall not exceed 250 lb. per square inch. The thickness shall be not less than two-thirds that specified for brick walls, and in no case less than 8 ins. All such walls shall be reinforced with steel running both horizontally and vertically. The amount of reinforcement shall be not less than one-fifth of 1 per cent of the cross section of the wall, and shall be equally disposed near each face of the wall; except that in walls or partitions 8 in. or less in thickness, the reinforcement may be placed as a single layer in the middle. Reinforcement shall be spaced not more than 18 in. apart. Additional reinforcement shall be placed around wall openings, and all vertical and horizontal reinforcement shall be wired or have other mechanical bond at intervals not exceeding 18 in. in either direction.

General.—The 1916 Report of the Joint Committee on Concrete and Reinforced Concrete shall be followed in the design of girderless slabs, and it shall be the final authority in interpreting these specifications and applying same to unusual cases of spans and loading.

## COMPARATIVE COSTS OF STEEL AND CONCRETE BRIDGES.

Interesting comparative figures on the cost of steel and concrete bridges are given by A. W. Conover, Engineer, Bureau of Bridges of the Illinois State Highway Department, in the November Illinois Highways. According to these figures the first cost of a steel bridge in many instances now exceeds the first cost of a concrete structure. Table I shows the bids actually submitted and the comparative estimates for a number of structures for which alternate plans for both steel and concrete bridges were prepared.

These plans were prepared by the Bureau of Bridges during the years 1914-1916. They cover only those cases where there was some doubt as to whether a concrete or steel bridge would prove more economical for the site in question. For the majority of bridge sites, the advantage of the one type of bridge construction over the other is apparent from the comparative estimates for a concrete and a steel bridge.

TABLE I.—COMPARISON BETWEEN COSTS OF STEEL AND CONCRETE BRIDGES.

| Name of Bridge. | Location. | Total span (ft.). | Estimated Costs. Steel. | Estimated Costs. Concrete. | Low Bids Received. Steel. | Low Bids Received. Concrete. |
|---|---|---|---|---|---|---|
| Sneakout | Cave Township, Franklin County | 50 | $ 1,930 | $ 2,160 | $ 1,863 | *$ 1,869 |
| Bluff City | Woodland and Hickory Townships, Fulton and Schuyler Counties | 60 | 2,880 | 3,250 | 2,699 | *2,989 |
| Burtons | Nunda Township, McHenry County | 400 | 15,300 | 17,000 | 13,705 | 14,000 |
| Mt. Moriah Church | La Grange and East Fork Townships, Bond and Montgomery Counties | 60 | 3,180 | 3,210 | *2,552 | 2,900 |
| Brady | Pea Ridge Township, Brown County | 60 | 2,855 | 3,660 | *2,422 | 3,229 |
| Popham | Pleasant Grove Township, Coles County | 50 | 2,240 | 2,050 | 1,760 | *1,840 |
| Pond Creek | Frankfort and Lake Creek Townships, Franklin and Williamson Counties | 30 | 1,335 | 1,500 | *947 | No returns<br>Not included in totals. |
| Pinney | Bolo Township, Washington County | 30 | 1,300 | 1,445 | *1,250 | 1,250 |
| Corrigan | Amity Township, Livingston County | 150 | 7,950 | 7,550 | 7,200 | 7,600 |
| Troumbower | Buckhart and Mt. Auburn Townships, Christian County | 50 | 1,970 | 2,000 | 1,224 | 1,499 |
| Kellogg | Clintonia Township, DeWitt County | 50 | 2,275 | 2,360 | 2,350 | No returns<br>Not included in totals. |
| Dunn Prairie | Ewing Township, Franklin County | 55 | 2,000 | 2,125 | 1,948 | *1,913 |
| Grassy Creek | Saline Township, Williamson County | 36 | 985 | 1,125 | No returns<br>Not included in totals. | *1,098 |
| Sedgwick | Lisbon Township, Kendall County | 36 | 1,695 | 1,730 | 1,690 | *1,685 |
| Watson | Cherry Valley and Monroe Townships, Winnebago and Ogle Counties | 150 | 7,620 | 6,640 | 6,855 | *5,999 |
| Richards | Sheridan Township, Logan County | 30 | 1,272 | 1,208 | No returns<br>Not included in totals. | *1,200 |
| Stuhan | Sheridan and West Lincoln Townships, Logan County | 30 | 1,520 | 1,445 | No returns<br>Not included in totals. | *1,400 |
| New Canton | Pleasant Vale Township, Pike County | 150 | 11,220 | 9,680 | 11,800 | *9,343 |
| Melton County Line | Westfield and Kansas Townships, Clark and Edgar Counties | 50 | 3,350 | 3,310 | 2,897 | *2,680 |
| No. 1 Centennial | Douglas Township, Iroquois County | 120 | 7,560 | 10,410 | *9,300 | 9,980 |
| McCue | Greenwood Township, McHenry County | 50 | 2,415 | 2,515 | *2,580 | 2,423 |
|  | Totals | 1,691 | $82,852 | $86,373 | ....... | ....... |
|  |  | 1,521 | ....... | ....... | $71,745 | $71,200 |

*Denotes the award of the contract.

The last eight bridges in the table were contracted for in 1916, and in a number of these cases both the estimates and low bids received indicate that a concrete bridge is cheaper in first cost than a steel bridge. The one notable exception, the No. 1 Centennial bridge in Douglas Township, Iroqois County, is explained by the fact that a concrete bridge for this site involved the construction of a long central pier about 22 ft. high, built on a skew. In the case of the Centennial No. 1 bridge, however, it would have been possible to justify the selection of a concrete bridge on the basis of cheaper ultimate cost.

The directors of the Union Depot Co., of St. Paul, Minn., have decided to modify the plans for the proposed structure so as to reduce the cost from $15,000,000 to $11,000,000.

## DETAILED COST OF 113-FT. REINFORCED CONCRETE THROUGH GIRDER BRIDGE BUILT NEAR DOUGLAS, ARIZ.

During 1915-1916 the State Highway Department of Arizona constructed a 113-ft. concrete bridge over the Whitewater River near Douglas, Ariz. The structure was of the through girder type, and consisted of two spans 37 ft. 6 in. each and one span 38 ft. It replaced a 90-ft. frame bridge. Very complete cost data on the work are given in the recently issued annual report of Lamar Cobb, State Engineer, from which the matter that follows is taken.

### Subaqueous Foundations.

The subaqueous foundations required 236.5 cu. yd. of excavation and 223.7 cu. yd. of concrete. The detailed cost of this work was as follows:

Excavation.

| | Total. | Per cu. yd. excavation. (236.5 cu. yd.) | Per cu. yd. concrete. (223.7 cu. yd.) |
|---|---|---|---|
| Foreman | $ 200 | $0.85 | $0.90 |
| Laborers | 649 | 2.74 | 2.91 |
| Drivers | 51 | .21 | .23 |
| Teams | 24 | .10 | .11 |
| Miscellaneous | 153 | .65 | .68 |
| Tools | 71 | .30 | .32 |
| Total | 1,148 | $4.85 | $5.15 |
| Pumping— | | | |
| Foreman | $ 28 | $0.118 | $0.125 |
| Laborers | 200 | .85 | .20 |
| Fuel | 29 | .121 | .129 |
| Miscellaneous | 48 | .200 | .214 |
| Tools | 148 | .605 | .660 |
| Total | $ 453 | $1.914 | $2.028 |
| Less chargeable to concreting | 18 | .077 | .083 |
| Net total | $ 434 | $1.837 | $1.945 |

Shoring.

Sheet piles driven, 340; average length, 10 ft. Cost per lin. ft., 3,380 lin. ft. at 20¾ ct. Board feet driven, 8.88 M ft. at $78.60. Cost per lin. ft. labor only, 14.6 ct.

| | Total. | Per M ft., B. M. | Per cu. yd. excavation. (236.5 cu. yd.) | Per cu. yd. concrete. (223.7 cu. yd.) |
|---|---|---|---|---|
| Foreman | $ 45 | $ 5.05 | $0.19 | $0.20 |
| Carpenters | 8 | .87 | .033 | .035 |
| Laborers | 182 | 20.35 | .773 | .820 |
| Lumber | 255 | 28.80 | 1.085 | 1.146 |
| Nails | 4 | .42 | .002 | .003 |
| Miscellaneous | 114 | 12.80 | .480 | .507 |
| Tools | 63 | 7.07 | .265 | .281 |
| Teams and drivers | 29 | 3.24 | .122 | .128 |
| Total | $698 | $78.60 | $2.95 | $3.12 |

Piling.

Excavation, 69.9 cu. yd. at $1.45. Concrete, 7.10 cu. yd. at $1.41. Number piles driven, 17; length, 8 ft.; cost per lin. ft., $0.7362. Penetration, 5 ft.; cost per ft. penetration, $1.145. Board feet driven, 0.896 M B. ft. Cost per M B. ft., $111.50. Lumber per lin. ft., $0.2275. Lumber per M B. ft., $34.40. Cost driving only, per lin. ft., $0.5075. Cost driving only, per M B. ft., $77.00.

| | Total. | Per cu: yd. concrete. (223.7 cu. yd.) |
|---|---|---|
| Foreman | $ 4.00 | $0.017 |
| Laborers | 29.00 | .129 |
| Teams | 8.00 | .034 |
| Drivers | 8.00 | .034 |
| Tools | 17.00 | .074 |
| Miscellaneous | 5.00 | .022 |
| Total labor | $69.16 | $0.310 |
| Lumber | 30.85 | .138 |
| Total | $100.01 | $0.448 |

CONCRETING MATERIALS TO MIXER.

Yardage, loose material, not including slag: 143 cu. yd.

| | | Total. | Cost per yd. of loose material. | |
|---|---|---|---|---|
| Foreman | $8.63 | | | |
| Miscellaneous | 3.68 | $12.00 | $0.086 | $0.055 |
| Laborers | | 65.00 | .449 | .289 |
| Tools | | 3.00 | .018 | .012 |
| Total | | $80.00 | $0.553 | $0.356 |

CONCRETING MIXING—OPERATION.

| | Total. | Per cu. yd. concrete. (223.7 cu. yd.) |
|---|---|---|
| Foreman | $ 6.00 | $0.024 |
| Laborers | 45.00 | .202 |
| Miscellaneous | 158.00 | .708 |
| Repairs | 57.00 | .253 |
| Tools | 33.00 | .147 |
| Fuel, 22 gal. at 17 ct. | 4.00 | .017 |
| Water, 20,715 gal. at $1.42 per M. gal. | 29.00 | .132 |
| Total | $332.00 | $1.483 |

CONCRETING MIXING—MATERIALS.

Number sacks cement per yard concrete, 3.43 sacks; net cost per sack cement, $0.75; cu. yd. sand per yard concrete, $0.412 cu. yd.; cu. yd. sand per yard concrete, $0.412 cu. yd.; cost per yard of sand, $2.135; cu. yd. slag per yard concrete, $0.613 cu. yd.; cost per yard of slag, $1.105; cu. yd. gravel per yard concrete, $0.232 cu. yd.; cost per yard of gravel, $2.100; per cent of slag to total concrete, 61.25 per cent; average gallons water per yard concrete, 90¼ gal.; cement, $648.76—767 sacks; less sacks returned, $72.05.

| | Total. | Per cu: yd. concrete. (223.7 cu. yd.) |
|---|---|---|
| Net cost of cement | $ 577.00 | $2.58 |
| Sand, 91.9 cu. yd. at $2.135 | 196.00 | .878 |
| Slag, 136.9 cu. yd. at $1.105 | 151.00 | .676 |
| Gravel, 52.0 cu. yd. at $2.10 | 109.00 | .488 |
| Total | $1,033.00 | $4.622 |

CONCRETING FORMS.

| | | | |
|---|---|---|---|
| Foreman | $9.37 | | |
| Miscellaneous | 4.58 | $14.00 | $0.062 |
| Laborers | | 86.00 | .385 |
| Tools | | 9.00 | .039 |
| Total | | $ 109.00 | $0.486 |

CONCRETING—PLACING.

| | | | |
|---|---|---|---|
| Foreman | $3.61 | | |
| Miscellaneous | 1.46 | $ 5.00 | $0.023 |
| Laborers | | 26.00 | .119 |
| Tools | | 4.00 | .019 |
| Total | | $ 35.00 | $0.161 |
| Add cost of pumping | | 18.00 | .081 |
| Grand total placing | | $ 54.00 | $0.242 |

SUMMARY.

Total subaqueous excavation, $2,280.90—cost per yard excavation, $9.637 per cu. yd.; concrete, $10.215; total subaqueous concrete, $1,607.53—cost per yard concrete, $7.183; total subaqueous piling, $100.01—cost per M. ft., $111.50; lin. ft., $0.77; yard concrete, $0.448; grand total subaqueous foundations, $3,988—cost per yard concrete, $17.846.

SUBAQUEOUS FOUNDATIONS: COMPARISONS OF COST—EXCAVATION.

The following figures are for costs per yard excavation:

| | East abutment. | West abutment. | Pier No. 1. | Pier No. 2. |
|---|---|---|---|---|
| Excavation | $ 1.65 | $ 8.00 | $ 4.71 | $ 2.90 |
| Pumping | .76 | 3.03 | 1.46 | 1.54 |
| Shoring | 3.57 | 2.89 | 2.93 | 2.68 |
| Piling | ...... | 1.45 | ...... | ...... |
| Total | $ 5.98 | $15.37 | $ 9.10 | $ 7.12 |

SUBAQUEOUS FOUNDATIONS: COMPARISONS OF COSTS—CONCRETE.

The following figures are for costs per yard concrete:

| | East abutment. | West abutment. | Pier No. 1. | Pier No. 2. |
|---|---|---|---|---|
| Excavation | $ 1.375 | $ 7.75 | $ 5.50 | $ 3.48 |
| Pumping | .63 | 2.90 | 1.77 | 1.845 |
| Shoring | 2.965 | 2.77 | 3.49 | 3.205 |
| Piling | .... | 1.41 | .... | .... |
| Total excavation | $ 4.97 | $14.83 | $10.76 | $ 8.53 |
| To mixer | .324 | .339 | .42 | .31 |
| Mixing operations | 1.855 | 1.346 | 1.475 | 1.42 |
| Mixing materials | 5.65 | 4.36 | 4.56 | 4.81 |
| To forms | .143 | .329 | .86 | .42 |
| Placing | .138 | .478 | .055 | .24 |
| Total concreting | $ 7.52 | $6.852 | $ 7.37 | $ 7.20 |
| Grand total | $12.48 | $21.682 | $18.13 | $15.73 |

### Superaqueous Foundations.

The original design, which called for reinforced concrete walls and columns resting on 24-in. footings at the bottom of the subaqueous excavation, was not followed in the construction. The successful placing of the reinforcing and concrete as in the original design would have required a water-tight sheet-piling, and a concrete seal at the bottom, and a type of sheeting that would stand without bracing. Sheet-steel piling would have served this purpose, but was not obtainable, so the original design was abandoned. Instead, that part of the foundations that were below water level were cast in mass-concrete, and that part of the foundations that were above the water level were put in according to the plans. This required that the reinforcing steel be cut to new lengths. The East abutment did not extend to sufficient depth to establish a firm foundation, and an extra subfooting was put under it, although the plans did not call for that depth. The only difficulty experienced in pouring this part of the foundation was that the forms for the columns were not strong enough to stand the weight of the concrete, and they bulged in spite of all that could be done to tie and brace them in place. The columns were on a skew, and the concentration of pressure on the sharp angles overcame the pressure on the flat angles, so that the columns deformed along the sharp angles. One column skewed so badly it was torn down and replaced, while all of them showed more or less deformation on the sharp angles. It is thought that if a heavy piece of timber had been placed along the sharp angles, and tied in securely, the trouble might have been prevented, but no provision had been made for such timber in the plans of the forms. The parapet placed on the abutments as a continuation of the curb on the girders did not allow sufficient play to take care of the expansion and cracks have developed in the parapet, especially on the east end.

The superaqueous foundations required 810 cu. yd. of excavation and the placing of 87 cu. yd. of concrete.

The yardage as to excavation, represents the dry excavation for the abutments. The excavation on the west end was through clay, while on the east end it was through hard gravel, requiring blasting to loosen it. Both excavations, after loosening, were taken out with scrapers. The yardage as to concrete is for the two abutments only.

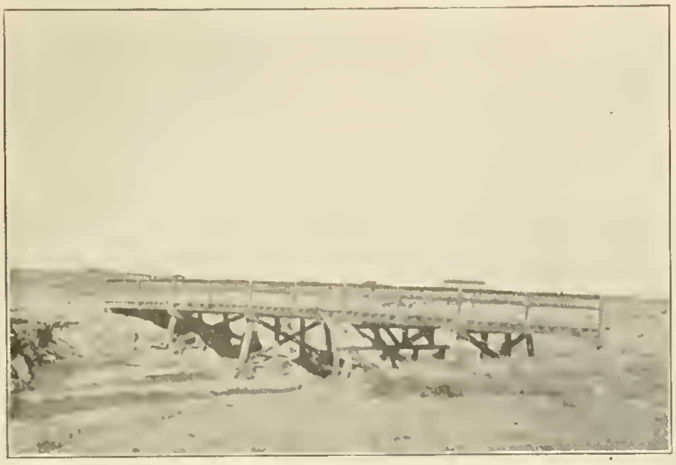


Fig. 1—Old Frame Structure.

| | Total. | Per cu. yd. excavation. | Per cu. yd. concrete. |
|---|---|---|---|
| Foreman | $ 53.00 | $0.066 | $0.613 |
| Laborers | 239.00 | .295 | 2.740 |
| Drivers | 92.00 | .114 | 1.059 |
| Teams | 92.00 | .114 | 1.059 |
| Explosives | 14.00 | .017 | .161 |
| Miscellaneous | 62.00 | .077 | .715 |
| Tools | 37.00 | .045 | .426 |
| Total | $539.00 | $0.7280 | $6.773 |

### FORMS—FRAMING AND ERECTING.

Yardage, concrete, 120 cu. yd., based on total concrete in superaqueous foundations; board ft. framed, 4,720 M. B. ft. at $81; square feet covered, 2 488 sq. ft. at $0.1535; board feet actually used, 2,360 M. B. ft., $162; cost of lumber actually used, 2.360 M. B. ft. at $28.40; ratio feet framed to feet used, 2:1; labor cost only, per sq. ft., $0.03; per M. B. ft., $78.90, framed.

| | Total. | Per cu. yd. concrete. |
|---|---|---|
| Foreman | $ 20.00 | $0.1709 |
| Carpenters | 91.00 | .7625 |
| Laborers | 88.00 | .7310 |
| Miscellaneous | 104.00 | .8640 |
| Tools | 3.00 | .0228 |
| Total labor | $306.00 | $2.5512 |
| Lumber | 67.00 | .5580 |
| Nails | 9.00 | .0760 |
| Total materials | $ 76.00 | $0.6340 |
| Total labor and materials | $382.00 | $3.1852 |

### FORMS—STRIPPING.

Cost per M. B. ft., framed, $14.00; cost per square foot, $0.0265.

| | | |
|---|---|---|
| Foreman | $ 11.00 | $0.0887 |
| Carpenters | 4.00 | .0334 |
| Laborers | 48.00 | .3965 |
| Miscellaneous | 3.00 | .0267 |
| Tools | 1.00 | .0081 |
| Total | $ 66.00 | $0.5534 |

### TOTAL FORMS: FRAMING AND ERECTING AND STRIPPING.

Total cost, $449; cost per cu. yd. concrete $3.7386; cost per M. B. ft., $95; cost per square foot, $0.18; cost for labor only, per M. B. ft., $78.80 framed; cost for lumber only, per M. B. ft., $16.20 framed, net cost; per sq. foot, $0.035 (net cost of lumber); actual B. ft. lumber used, 2.360 M. B. ft.; first cost of lumber used, $93.05 per M. B. ft., $39.40; less credits for scrap recovered, $26 per M. B. ft., $11; net cost of lumber, $67.05 per M. B. ft., $28.40; ratio first cost to credits, 1:0.279.

### CONCRETING: TO MIXER.

Yardage, concrete, 120.0 cu. yd. at $0.5689; loose materials, 130.4 cu. yd. at $0.5225.

| | | Total. | Per cu. yd. concrete. |
|---|---|---|---|
| Foreman | $7.47 | | |
| Miscellaneous | 3.22 | $ 11.00 | $0.0892 |
| Laborers | | 55.00 | .4580 |
| Tools | | 3.00 | .0217 |
| Total | | $ 69.00 | $0.5689 |

### CONCRETING: MIXING—OPERATION.

| | Total. | |
|---|---|---|
| Foreman | $ 4.00 | $0.0295 |
| Laborers | 24.00 | .1990 |
| Miscellaneous | 108.00 | .8980 |
| Repairs | 38.00 | .3125 |
| Tools | 20.00 | .1656 |
| Fuel, 14½ gal. at $0.169 | 2.00 | .0205 |
| Water, 13,435 gal. at $1.308 M | 17.00 | .1463 |
| Total | $210.00 | $1.7714 |

### CONCRETING—MIXING MATERIALS.

Number sacks cement per yard concrete, 4 sacks; net cost per sack cement, $0.74; cu. yd. sand per yard concrete—0.37 cu. yd.; cost of sand per yard sand, $2.18; cu. yd. gravel per yard concrete, 0.72 cu. yd.; cost of gravel per yard gravel, $2.145; average gal. water per yard concrete, 120 gal.; cement, 475 sacks at $0.833, $398.67; less credit for sacks returned, $44.95.

| | Total. | Per cu. yd. concrete. |
|---|---|---|
| Net cost of cement at $0.74 | $354.00 | $2.915 |
| Sand, 44.3 cu. yd. at $2.18 | 97.00 | .806 |
| Gravel, 86.1 cu. yd. at $2.145 | 184.00 | 1.535 |
| Total | $635.00 | $5.286 |

### CONCRETING FORMS.

| | | | |
|---|---|---|---|
| Foreman | $7.98 | | |
| Miscellaneous | 3.02 | $ 11.00 | $0.0916 |
| Laborers | | 39.00 | .3220 |
| Tools | | 4.00 | .0346 |
| Total | | $ 54.00 | $0.4482 |

### CONCRETING—PLACING.

| | | | |
|---|---|---|---|
| Foreman | $3.22 | | |
| Miscellaneous | 1.29 | $ 5.00 | $0.0375 |
| Laborers | | $ 25.00 | .2055 |
| Tools | | ..... | .0015 |
| Total | | $ 30.00 | $0.2445 |

### REINFORCING—BENDING.

Yardage, concrete, 120.0 cu. yd.; pounds steel bent, 13,141 lb.

| | | Per cu. yd. | Per lb. |
|---|---|---|---|
| Foreman | $ 5.00 | $0.0427 | $0.00039 |
| Laborers | 28.00 | .2330 | .00212 |
| Tools | 5.00 | .0405 | .00037 |
| Totals | $ 38.00 | $0.3162 | $0.00288 |

### REINFORCING—PLACING.

| | | | |
|---|---|---|---|
| Foreman | $ 33.00 | $0.278 | $0.00254 |
| Laborers | 43.00 | .358 | .00327 |
| Tools | 1.00 | .001 | .00006 |
| Miscellaneous | 24.00 | .209 | .00185 |
| Total labor | $101.00 | $0.846 | $0.00772 |
| Steel | 297.00 | 2.475 | .02260 |
| Total | $398.00 | $3.321 | $0.03032 |
| Add cost of bending | 38.00 | .3162 | .00288 |
| Total cost of reinforcement | $436.00 | $3.6372 | $0.03320 |

### SUMMARY.

| | | Per yard concrete. |
|---|---|---|
| Total excavation | $ 589.44 | $ 4.92 |
| Total forms | 448.86 | 3.74 |
| Total concreting | 996.09 | 8.32 |
| Total reinforcing | 436.19 | 3.63 |
| Grand total | $2,470.58 | $20.61 |

### RECAPITULATION—SUBSTRUCTURE.

| Account. | Cost. | Pctg. of total cost of bridge. | Cu. yd. | Cost per yard. |
|---|---|---|---|---|
| Subaqueous foundations | $3,988.44 | 33.25 | 223.7 | $17.85 |
| Superaqueous foundations | 2,470.58 | 20.55 | 120.0 | 20.61 |
| Total substructure | $6,459.02 | 53.80 | 343.7 | $18.80 |

Cost per yard subaqueous concrete, $17.85; cost per yard superaqueous concrete, neglecting reinforcements, $16.98. Average mix used in subaqueous concrete: 1 part cement, 3.2 parts sand, 4.8 parts gravel, 1.8 slag. Average mix used in superaqueous concrete: 1 part cement, 2 parts sand, 4 parts gravel.

## Superstructure.

**Falsework.**—The original plans for falsework did not allow of any adjustment between the posts and caps, and it was necessary to make hard-wood wedges, and purchase additional timbers to serve as bottom caps. Twenty piles were also driven over the channel of the creek.

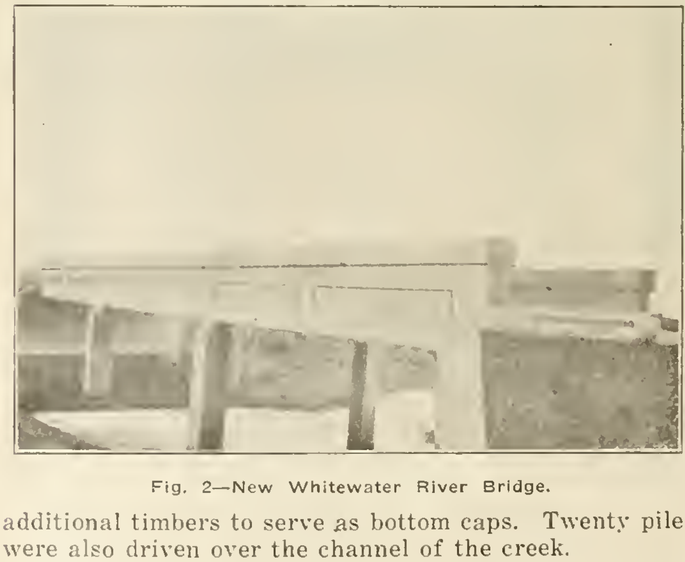


Fig. 2—New Whitewater River Bridge.

**Girder Forms.**—The failure of the girder forms to stand up under the strain of the pouring of the concrete caused the resulting girder to have a decidedly wavy appearance. The cause of this lay in the fact that the inside forms had no direct support, but relied on the outside forms to prevent any motion of the inside forms without a corresponding movement of the outside forms, but did not prevent both forms from moving laterally together. Not sufficient lumber was provided to prevent such lateral movement and when the concrete was poured, and the short legs under the inside forms were of necessity removed, the whole girder warped as a result of the unsupported weight on the inside. On the second and third spans, the brackets were left off the cross-pieces since they served no useful purpose. On these spans, the inside forms dropped, as on the first. but without pulling the outside forms so badly out of place. If it had been possible to pour the floor first, and then set the girder forms on the floor, this trouble might have been prevented, but the nature of the reinforcement did not allow casting the floor and curb-line separately from the girders, and that method was impracticable. If sufficient timbers had been provided to allow hanging both the girder forms from cross-timbers supported on posts resting on the falsework, it would again have been possible to avoid the trouble, but such timbers were not available.

An effort was made to put the forms up in sections, in order to save expense, but this plan failed because of the recessed corners at the top and bottom of the inside panels where the panels joined the coping and the curb. The forms caught in these recesses and prevented swinging the forms away after pouring. Because of this, each inside post had to be torn down before the panels could be moved. The same applies to the outside posts, but in a lesser degree, since the outside posts were of one piece, while the inside posts were in three pieces.

**Concreting.**—The first span was poured by dumping the buggies into a chute and shoveling from the chute to the forms, in an effort to save the forms from vibration as much as possible. Since this did not seem to have any effect, the rest of the bridge was poured by constructing a trestle work level with the tops of the forms and dumping directly into the forms.

**Reinforcing.**—The reinforcing presented some difficulty on account of its complexity, which ran up the cost of placing. The bars were spaced by small concrete bricks, and every effort was made to conform to the cross-section shown on the plans. In bending, the only trouble encountered was in the stirrups. The Bates Tyer used worked in a satisfactory manner, but the ties furnished were too light for the heavy steel, and broke easily under strain.

### FORMS—FRAMING AND ERECTING.

Yardage concrete, 171 cu. yd.; board feet framed, 10.221 M. B. ft.; actual board feet used, 7.679 M. B. ft., $27.65; square feet covered, 5,339 sq. ft.; total cost per M. B. ft. actually used, $110; labor cost only per M. B. ft. actually used, $80; ratio feet framed to feet used, 1.34:1.

| | Total. | Per cu. yd. concrete. | Per M. B. ft. framed. | Per sq. ft. |
|---|---|---|---|---|
| Foreman | $ 65.00 | $0.382 | $ 6.47 | $0.0123 |
| Carpenters | 184.00 | 1.078 | 18.00 | .0346 |
| Laborers | 281.00 | 1.645 | 27.50 | .0528 |
| Miscellaneous | 74.00 | .432 | 7.30 | 0139 |
| Tools | 9.00 | .049 | .84 | .0016 |
| Total labor | $614.00 | $3.587 | $60.11 | $0.1152 |
| Lumber | 212.00 | 1.250 | 20.75 | .0399 |
| Nails | 20.00 | .110 | 1.92 | .0037 |
| Total forms | $845.56 | $4.947 | $82.78 | $0.1588 |

### FORMS—STRIPPING.

Cost of stripping per M. B. ft. framed, $10.51; cost of stripping per square foot, $0.02014.

| | | | | |
|---|---|---|---|---|
| Foreman | $ 14.00 | $0.0805 | $ 1.345 | $0.00258 |
| Carpenters | 7.00 | .0408 | .685 | .00131 |
| Laborers | 79.00 | .4610 | 7.725 | .01480 |
| Miscellaneous | 4.00 | .0239 | .400 | .00077 |
| Tools | 3.40 | .0212 | .355 | .00068 |
| Total | $107.00 | $0.6274 | $10.510 | $0.02014 |

### TOTAL FORMS—FRAMING, ERECTING AND STRIPPING.

Total cost. $952.99; cost per cu. yd. concrete, $5.5744; cost per M. B. ft. framed. $93.29; cost per square foot covered. $0.17894; cost of labor only. per M. B. ft. framed, $70.50; materials per square foot. $0.1350; cost of materials only. per M. B. ft. framed, $22.79; per square foot, $0.04394; first cost of lumber used. $300.10; per M. B. ft., $39.05; less credits for scrap recovered. $88; per M. B. ft., $11.40; net cost of lumber, $212.10 per M. B. ft., $27.65; ratio first cost to credits, 1: 0.292.

The above costs are for the costs of framing both the girder, forms and the floor. Complete figures as to cost of the floor were not kept, but an estimate, based on the labor distribution for the first span shows the following costs per square foot:

| | |
|---|---|
| Floor, 2,500 sq. ft. at $0.07 | $175.00 |
| Girders, 2,830 sq. ft. at $0.2330 | 671.00 |
| From which: | |
| Cost of laying floor, per sq. ft. | $0.0700 |
| Cost of forms for plain surfaces | .1535 |
| Cost of forms for paneled surfaces | .2330 |

These figures are for framing and erecting only, and do not include cost of stripping.

### FALSEWORK: FRAMING AND ERECTING: BENTS.

Yardage, concrete, 171 cu. yd.; board feet framed, 12.919 M. B. ft.; board feet actually used, 8.902 M. B. ft.

| | Total. | Per cu. yd. concrete. | Per M. B. ft. framed. |
|---|---|---|---|
| Foreman | $ 13.00 | $0.0760 | $ 1.0075 |
| Carpenters | 37.00 | .2160 | 2.8650 |
| Laborers | 74.00 | .4320 | 5.7300 |
| Miscellaneous | 17.00 | .0977 | 1.2800 |
| Tools | 2.00 | .0108 | .1348 |
| Total labor | $142.00 | $0.8325 | $11.0173 |
| Lumber | 260.00 | 1.5150 | 20.10 |
| Nails | 19.00 | .1150 | 1.46 |
| Total bents, F. and E. | $421.00 | $2.4625 | $32.5773 |

### FALSEWORK: BENTS: STRIPPING.

Cost of stripping per M. B. ft. framed, $4.2470; cost of stripping per cubic yard, $0.3207.

| | Total | Per cu. yd. concrete. | Per M. B. ft. framed. |
|---|---|---|---|
| Foreman | $ 8.00 | $0.0480 | $ .6350 |
| Carpenters | 8.00 | .0467 | .6200 |
| Laborers | 37.00 | .2145 | 2.8400 |
| Tools | ..... | .0028 | .0360 |
| Miscellaneous | 2.00 | .0087 | .1160 |
| Total | $ 55.00 | $0.3207 | $ 4.2470 |

### FALSEWORK: PILES, DRIVING.

Board feet driven, 1,280 B. ft.; linear feet driven, 320 lin. ft.

| | Total. | Per cu. yd. concrete. | Per M. B. ft. | Per lin. ft. |
|---|---|---|---|---|
| Foreman | $ 9.00 | $0.0543 | $ 7.28 | $0.0290 |
| Carpenters | 9.00 | .0555 | 7.43 | .0297 |
| Laborers | 56.00 | .3300 | 44.10 | .1765 |
| Miscellaneous | 12.00 | .0690 | 9.25 | .0370 |
| Tools | 36.00 | .2125 | 28.40 | .1135 |
| Teams | 9.00 | .0512 | 6.84 | .0274 |
| Drivers | 9.00 | .0512 | 6.84 | .0274 |
| Total labor | $141.00 | $0.8237 | $110.14 | $0.4405 |
| Lumber | 44.00 | .2580 | 31.45 | .1380 |
| Nails (drift pins) | 5.00 | .0295 | 3.95 | .0155 |
| Total piling | $190.15 | $1.1112 | $148.54 | $0.5940 |

### TOTAL FALSEWORK, FRAMING AND ERECTING, STRIPPING AND PILING—

Total cost, $665.66; cost per cu. yd. concrete, $3.8914; cost per M. B. ft. framed and driven, $57.88; board feet framed and driven, per M. B. ft., 11.5; cost of labor only, per M. B. ft., $29.40; per yard, $1.98; cost of materials only, per M. B. ft., $28.48; per yard, $1.9144; first cost of lumber used, $394.99; per M. B. ft., $38.99; less credits for scrap recovered, $91.27; per M. B. ft., $8.975; net cost of lumber, $303.72; per M. B. ft., $29.925; number of piles driven, 20; length, 16 ft.; size, 8x8.

### REINFORCING: BENDING.

Yardage, concrete, 171.0 cu. yd.; pounds steel bent, 30,947 lb.

| | Total. | Per cu. yd. concrete. | Per lb. |
|---|---|---|---|
| Foreman | $ 21.00 | $0.1235 | $0.00068 |
| Laborers | 152.00 | .8900 | .00492 |
| Tools | 26.00 | .1530 | .00085 |
| Miscellaneous | 11.00 | .0642 | .00035 |
| Total | $211.00 | $1.2307 | $0.00680 |

### REINFORCING: PLACING.

Yardage, concrete, 171.0 cu. yd.; pounds steel placed, 30,947 lb.

| | Total. | Per cu. yd. concrete. | Per lb. |
|---|---|---|---|
| Foreman | $ 27.00 | $0.1595 | $0.00089 |
| Laborers | 195.00 | 1.1385 | .00630 |
| Tools | 19.00 | .1085 | .00060 |
| Miscellaneous | 79.00 | .4630 | .00256 |
| Total labor | $320.00 | $1.8695 | $0.01035 |
| Steel | 875.00 | 5.1105 | .02825 |
| Total placing | $1,195.00 | $6.9800 | $0.03860 |
| Add cost of bending | 211.00 | 1.2307 | .00680 |
| Total cost of reinforcement | $1,404.00 | $8.2107 | $0.04540 |

### CONCRETING: TO MIXER.

Yardage, concrete, 171.0 cu. yd.; loose materials, 235.5 cu. yd. at $0.6280.

| | Total. | Per cu. yd. concrete. |
|---|---|---|
| Foreman | $ 23.00 | $0.1345 |
| Laborers | 117.00 | .6820 |
| Tools | 63.00 | .3690 |
| Total | $203.00 | $0.8675 |

### CONCRETING: MIXING OPERATION.

| | | |
|---|---|---|
| Foreman | $ 6.00 | $0.0363 |
| Laborers | 45.00 | .2665 |
| Water, 22,900 gal. at $1.41 per M | 32.00 | .1900 |
| Fuel, 6 gal. oil at $0.80 | 5.00 | .0281 |
| 80 gal. gas at $0.188 | 15.00 | .0879 |
| Repairs | 62.00 | .3640 |
| Miscellaneous | 97.00 | .5670 |
| Tools | 63.00 | .3690 |
| Total | $326.00 | $1.9088 |

### CONCRETING: MIXING MATERIALS.

Yardage, concrete, 171.0 cu. yd.; number sacks cement to one yard concrete, 5.14 sacks.

The number of sacks to one yard of concrete is more than usual. This is due to the fact that the floor on the first span was resurfaced, being improperly placed first running.

| | | |
|---|---|---|
| Net cost per sack cement | | $0.7775 |
| Number sacks used | | 880 |
| Cu. yd. sand per yard concrete | | 0.4825 |
| Cost of sand per yard sand | | $2.415 |
| Cu. yd. gravel per yard concrete | | 0.8950 |
| Cost of gravel per yard gravel | | $2.410 |
| Average gal. water per yard concrete | | 134 |
| Cement, 880 sacks at $0.8750 | $769.83 | |
| Less credit for sacks returned | 85.29 | |

| | Total. | Per cu. yd. concrete. |
|---|---|---|
| Net cost of cement at $0.7775 | $685.00 | $4.00 |
| Sand, 82.5 cu. yd. at $2.415 | 199.00 | 1.165 |
| Gravel, 153 cu. yd. at $2.41 | 369.00 | 2.160 |
| Total | $1,253.00 | $7.325 |

### CONCRETING: TO FORMS.

| | | |
|---|---|---|
| Foreman | $ 18.00 | $0.1081 |
| Laborers | 90.00 | .5275 |
| Tools | 14.00 | .0808 |
| Total | $122.00 | $0.7164 |

Average length of haul, 60 ft. Cost per foot per yard, $0.01194.

### CONCRETING: PLACING.

| | | |
|---|---|---|
| Foreman | $ 18.00 | $0.1047 |
| Laborers | 90.00 | .5230 |
| Tools | 2.00 | .0182 |
| Total | $110.00 | $0.6459 |

CONCRETING—MISCELLANEOUS.

| | Total. | Per cu. yd. concrete. |
|---|---|---|
| Finishing: Cost of labor only | $ 68.17 | $0.3990 |

The surface was never completely finished with carborundum bricks, as was originally intended, hence costs per square foot of area are not available.

| | Total. | Per cu. yd. concrete. |
|---|---|---|
| Expansion joints—Labor only | $ 10.00 | $0.0615 |
| Plates and rockers | 65.00 | .3820 |
| Asphaltum, 40 gal. at 50 cts | 20.00 | .1170 |
| Tar paper, four rolls | 9.00 | .0526 |
| Proportion miscellaneous and office | 4.00 | .0283 |
| | $110.0 | $0.6414 |

RECAPITULATION: SUPERSTRUCTURE.

| | Total. | Per cu. yd. concrete. |
|---|---|---|
| Forms | $ 953.00 | $ 5.5744 |
| Falsework | 666.00 | 3.8944 |
| Reinforcement | 1,405.00 | 8.2107 |
| Concreting | 2,137.00 | 12.5040 |
| Total | $5,161.00 | $30.1835 |

The bridge was constructed by day labor under the direction of J. C. Ryan, Division Engineer of the State Highway Department. Laborers were paid $3 per 8-hour day and carpenters $4 per day. Teams and drivers were hired for $5 per day.

Gravel was secured from the Fairbanks beds. A few cars of screened sand were bought, but most of it was run-of-bank gravel and was creened on the ground. This gravel shows a very low voidage content.

Although this gravel was expensive, the superior results secured from it on account of its low voidage content, and general good qualities for mixing, compensate for the increased cost. The gravel cost $1 per ton f. o. b. Douglas, or $1.39 per yard. The average cost of unloading and hauling to site was 54½c per yard. The cost of the sand was the same. The sand shows a decided break in graduations from fine to coarse, and the coarse grains are sharp and angular.

The center line was established by iron bolts set in concrete plugs, and a main base line was run at right angles to the center line, with a line of targets on the west bank. The main base was run on the east bank, and a sub-base was also run on the west bank. The centers of piers and columns were established by triangulating for a three-point intersection. The error was about ½ in.

Cement used was the "El Toro" brand, shipped from El Paso in carload lots. Water was secured from the pipe line of the local water company, distant about 600 ft. from the site.

The bridge was designed by the State Engineer's office, which also prepared the plans for the falsework and forms, and ordered all lumber and steel and cement prior to beginning construction. The amount of lumber ordered proved inadequate and extensive purchases were made in the local market. The final elevation of the roadway was changed from Elev. 76 to Elev. 77, to allow for increased waterway.

## SOME INTERESTING EXAMPLES OF EUROPEAN CONCRETE BRIDGE DESIGNS.

Contributed by Albert M. Wolf.

Much has been written concerning the beauty and artistic appearance of European concrete bridges in the effort to make American engineers pay attention to the esthetic, as well as the theoretical and economical features of concrete bridges. It is gratifying to note that these efforts are bearing fruit, and that few structures of any importance are now being built, in the design of which the architectural treatment has been neglected.

The following interesting examples of European bridge designs are presented with a view of giving a pictorial substantiation of the contention that European bridges are artistic. Then also some noteworthy examples of the adaptability of concrete to the enlarging and widening of masonry bridges are given.

The structure shown in Fig. 1 is the Langweis viaduct in Switzerland which, when rise as well as span is considered, has the largest arch span in the world. The viaduct is made up of 314 ft. 11½ in. clear span, fixed-end arch over the gorge, and approaches made up of continuous girder spans, some of them over 50 ft. long. The arch has a rise of 134 ft. and is made up of two reinforced concrete ribs tied together by horizontal struts, the ribs supporting the framed bents of the roadway deck. This structure in spite of its great size possesses an appearance of lightness and grace which is commendable. Its unusual height and the light construction used in the superstructure being responsible therefor. Situated in a rugged and very mountainous country, an ornamental structure would have been out of place and consequently, the architectural treatment is very simple with plain yet graceful lines being used to bring out the artistic beauty of the bridge.

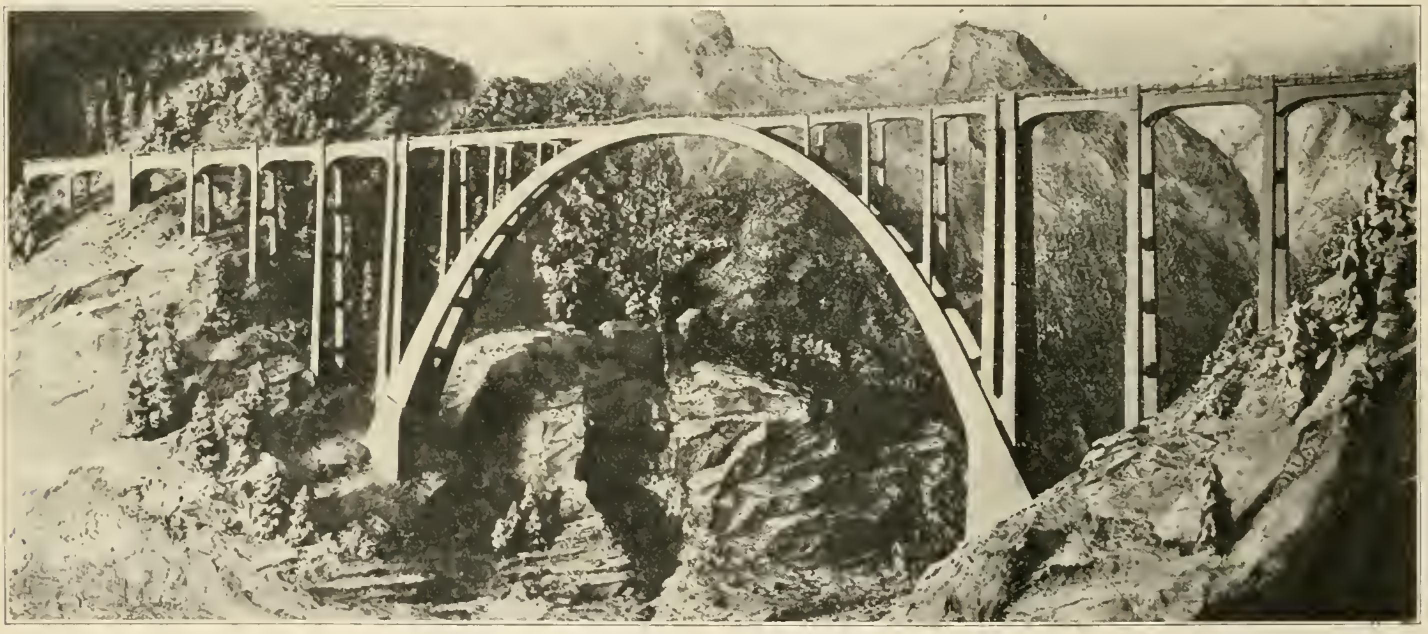


Fig. 1—Langweis Viaduct, Switzerland, Clear Span, 314 Ft. 11½ Ins.

Figures 2 and 3 give views of the main and approach spans of a highway arch bridge of rib construction built over the River Moselle near Noveant in 1907-8. This structure is an excellent example of the combination of lightness, graceful lines and artistic treatment of European arch bridges. The main arch spans are 154 ft., 131 ft. and 108 ft. long, while the approach spans are about 47 ft., 42 ft. and 39 ft. long. Each span is made up of four fixed end arch ribs of rectangular section, those in the three main spans being joined together by a continuous arched slab, framing into the bottom portion of ribs at the springing line and gradually rising, thus providing T-beam ribs to resist the bending moments induced in the arches and also stiffening the structure laterally.

Continuous girder spans are used quite often in Europe for highway bridges of span lengths which would not be considered economical in American practice. The

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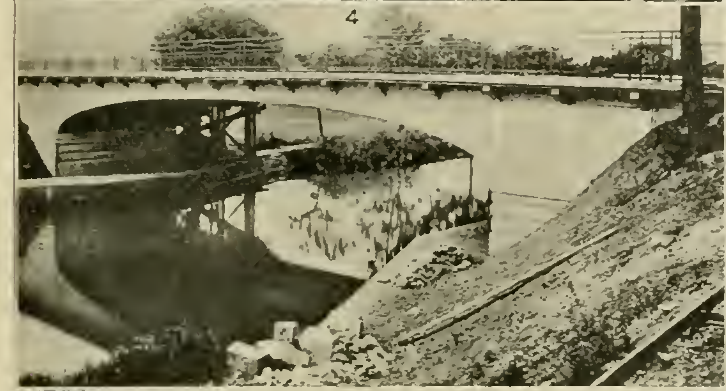

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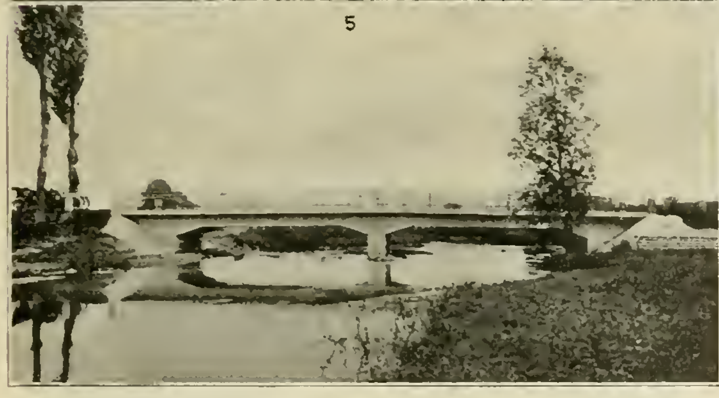

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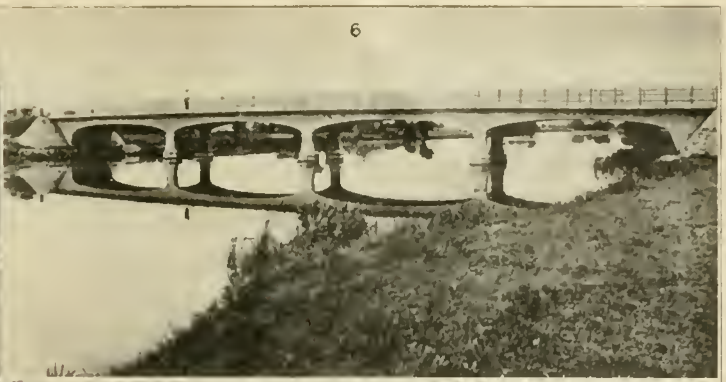

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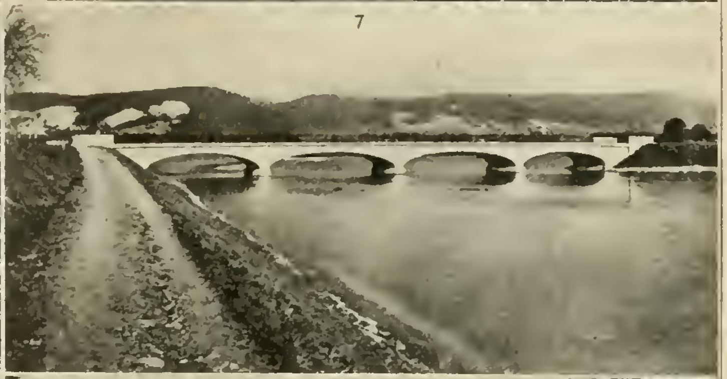

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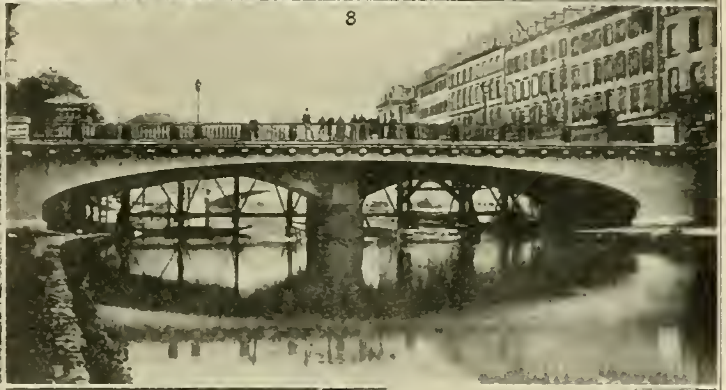
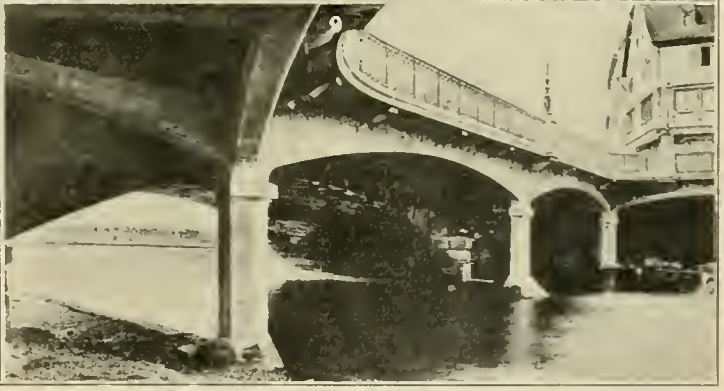




Examples of European Concrete Bridge Designs.

methods of design, however, take advantage of the continuous action developed in a number of spans and as a result girder spans of over 50-ft. are not uncommon.

In Fig. 4 is shown a single span highway bridge over the Moselle River at Moulin-Metz built in 1905, which consists of four fixed-end girders of 68 ft. 10 in. span, the under sides of girders being curved to give the bridge the appearance of an arch.

A 2-span continuous girder bridge supported on concrete piles is pictured in Fig. 5. This bridge is located at Ratsamhausen. In this particular structure, making a fairly low crossing of the stream, the girders were not arched but made straight with heavy fillets at the center pier and abutments.

The structure shown in Fig. 6 is located at Kreis-Schlettstadt, Germany. It is made up of four continuous girder spans, the girders having variable moments of inertia, being rigidly framed to elastic piers resting on concrete piles. The graceful curves given the underside of girders, together with the light piers, give the structure the appearance of a series of flat arch spans of extreme lightness.

In Fig. 7 another continuous girder bridge in August-Wghlan is illustrated. This structure with two spans of 41 ft. 8 in. and two 51 ft. 8 in. is carried on massive piers and abutments and partakes very much of the appearance of an earth fill spandrel arch bridge. The girders were designed as truly continuous over the piers and have a variable moment of inertia due to the curving of the bottom of girders.

Some very novel methods of widening existing masonry arches in the City of Strassburg in Alsace to meet new conditions are shown in Figs. 8 and 9. The former shows a 2-span stone masonry arch bridge increased in width by adding a narrow single span concrete arch on each side of the existing bridge. The other view is of the addition made to the White Tower bridge, a stone arch structure in 1903. The new work having a combined length of 410 ft., consists of a slab deck carried on transverse beams resting on the old structure at one end and framing into continuous fascia girders with variable moments of inertia. The reinforced concrete columns to which the girders are framed are carried on concrete pile foundations.

The writer is indebted to Ed. Zublin & Co., Engineers and Contractors of Strassburg, Alsace, for the photographs and data used in making up this article.

## CONSTRUCTION FEATURES, PLANT LAYOUT, METHODS AND COSTS OF CONSTRUCTING A REINFORCED CONCRETE WAREHOUSE AT LOS ANGELES HARBOR, CALIFORNIA.

Contributed by W. D. Jones.

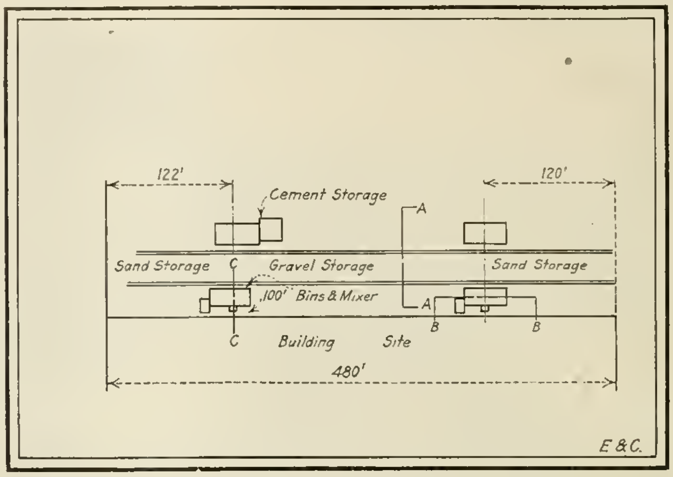
After deciding upon the class and size of structure desired for a warehouse, The Harbor Commission of Los Angeles purchased all materials to be used in its construction and advertised for bids for the performance of the work. The structure decided upon is 152 ft. wide and 484 ft. long and located in the rear of a transit shed 100 ft. wide on the water front at the harbor. Between the transit shed and the warehouse are located three loading tracks that serve the shed and a wide paved street both affording the best connection possible with the heart of the city.

View of Completed Building. Center Opening in End Is for Roadway to Elevators; Outside Openings for Tracks.

As constructed, the warehouse has six stories and basement, the latter being 7 ft. 9 in. high, first story is 14 ft. 6 in. high and upper stories 10 ft. high, all measurements being from floor surfaces. Provision is made for two railroad tracks in center of building between which is a loading platform 27 ft. wide. The elevations of these tracks is such that floors of cars are level with the first floor of the warehouse, this being the level of the loading platform. In order to provide rooms in the first floor and basement two longitudinal walls are provided parallel to tracks between the basement and second floor slabs, these being 6 in. thick in the basement story and 8 in. thick in the first story.

General View Showing Plan Arrangement; Basement Column Reinforcement in Place.

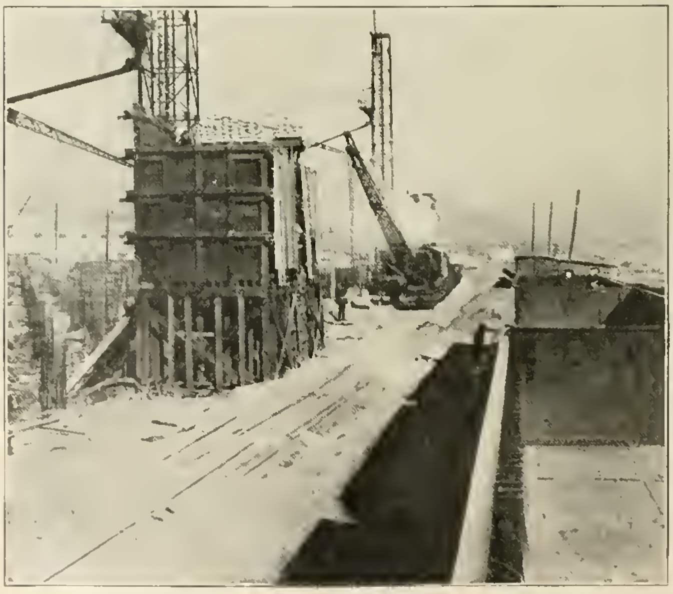
All outside walls are 8 in. thick in the basement and first stories and 6 in. thick in the upper stories. Seven partition walls 6 in. thick extend from basement to roof transversely with the building dividing it into 8 sections in the upper stories each approximately 60 ft. wide by 152 ft. long and into 16 sections approximately 42 ft. x 60 60 ft. in the first and basement stories. Four elevators are provided, each taking on or discharging material at the platform between the tracks and delivering to or taking from either of two sections or the upper floors between which it is constructed. Four flights of stairs on the outside of each side of building each also gives access to two sections. Each side of each section is provided with doors through which material may pass to or from outside hoists.



Relation of Mixers to Building and Material Storage.

Columns are octagonal in shape, 44 in. between parallel sides in basement and 20 in. in sixth story. Column caps and drop panels, which together flare from the size of the column into the floor slab, being 10 ft. 9 in. square at intersection with floor slab, were made uniform in first to fifth stories inclusive in order to simplify this feature of the form work, the basement and sixth story being the only ones where special construction was required.

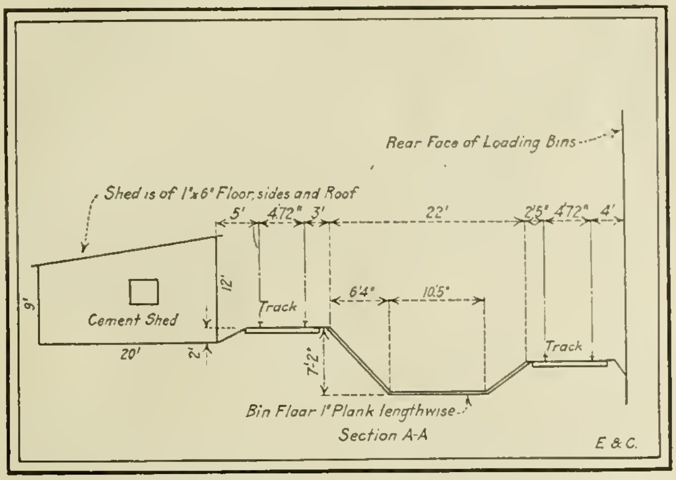
The basement floor slab is 5 in. thick and lays directly on the ground, first floor slab is 10 in. thick and other slabs 9 in. thick except between outside walls and first row of columns where they were made 10 in. thick. The roof slab is 6 in. thick in center and 7 in. thick next to walls. Floors were designed for a safe load of 400 lbs. per sq. ft. Columns are spaced 20 centers in a longitudinal and 21 ft. 2 in. in a transverse direction.



Ground Storage Pits, Mixer Bins and Crane for Loading Bins.

The specifications required the contractor to furnish and erect forms, pour concrete, place reinforcing and structural steel, finish floors, do the necessary excavating to saw off foundation piles which had previously been driven by the city, pour the concrete around these and backfill with a sand and shell material obtained nearby. All materials were furnished by the city F. O. B. cars at building site, and contractor was required to unload, sort and shelter these in a building provided by the city and be responsible for their incorporation in the structure in good condition.

This contract did not include sprinkler or electric systems, elevators, hoists, doors, windows, etc., which were put in under separate contracts.


Rear Face of Loading Bins
Shed is of 1"x6" Floor, sides and Roof
5'
4.72"
3'
22'
2.5'
4.72"
4'
9'
12'
Cement Shed
20'
2'
Track
6'4"
10.5'
7'-2"
Track
Bin Floor 1" Plank lengthwise
Section A-A
E & C.

Cross Section of Storage Bins Showing Relation to Cement Shed and Hoppers.

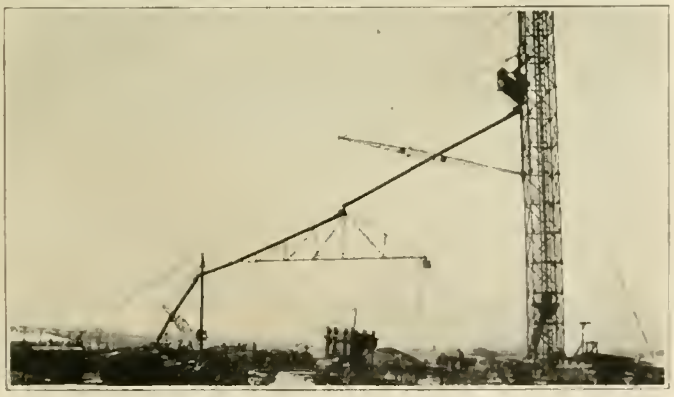
In the call for bids the approximate quantities were given as follows. Opposite each of these approximate quantities is set the unit price bid for the performance of this work.

| | |
|---|---|
| 27,000 cu. yds. of concrete in place .............. | $ 3.25 cu. yd. |
| 1,290 tons of reinforcing steel in place ........... | 12.05 tn. |
| 75 tons of structural steel in place ........... | 11.20 tn. |
| 475,000 sq. ft. floor finish ............................ | 0.01⅞ sq. ft. |
| Excavating, grading and cleaning up ........... | 4,098.00 lump sum |

## Concrete.

The materials used for concrete Portland cement, sand and gravel, the latter from ¼ in. to 1 in. in size, in order to work readily through the reinforcement, etc. The most of the concrete was of a 1:2:4: mixture, though some columns in the lower floors were of a richer mixture in order to reduce the size.

For the concrete pouring two Insley steel towers 160 ft. high were placed on one side of the building as shown in the sketch, and were provided with hoisting buckets of 24 cu. ft. capacity water measure. These were hoisted by 50 h. p. Crocker-Wheeler motor driven hoists with a line speed of 150 ft. per minute when pouring the lower floors, but when upper floors were reached it was found expedient to increase the speed of the hoisting buckets in order that the mixer not be forced to wait on the hoist. This was accomplished by rigging hoisting lines in such a manner as to connect directly to hoisting bucket with a single line instead of passing the line through a pulley on a bucket and fastening the end in the top of the tower. This worked a hardship on the hoist, especially the friction blocks, but these were watched closely and renewed often and no serious consequences were encountered.



Gravity Chutes and Boom for Swinging 50-ft. Section at End of Counter Weighted Chute.

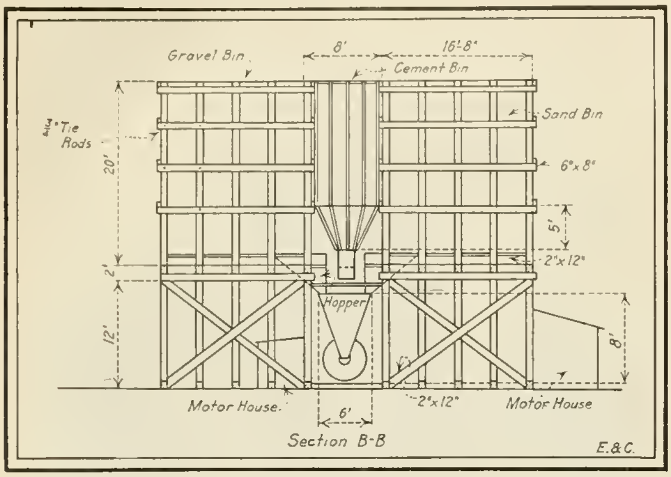
Each tower was equipped with a Bremer mixer having a capacity of 32 cu. ft. of loose material, a hoisting bucket of 22 cu. ft. capacity and a 50-ft. boom supporting 100 ft. of gravity spout. One extra piece of spout 50 ft. long and one about 20 ft. long were also provided and used at each plant when that plant was working.

On either side of each mixer was placed a rock bin and a sand bin each holding about 4 carloads of material and dumping directly by gravity into measuring bins which in turn dumped by gravity into mixer charging hopper. Directly over the charging hopper and between the sand and gravel bins was placed a cement bin. Into this the cement was dumped from sacks and passed by gravity through measuring bins as in case of sand and gravel, to the mixer. This method of handling the cement was not found to be as cheap as the old method of loading the mixer by cheap labor and was consequently later abandoned. There is no reason, however, that it should not have been successful had it been properly operated.

Method of Placing Vertical Rods in Column Spirals; Man on Top Lowering Rods into Spiral and Man on Bottom Tying.

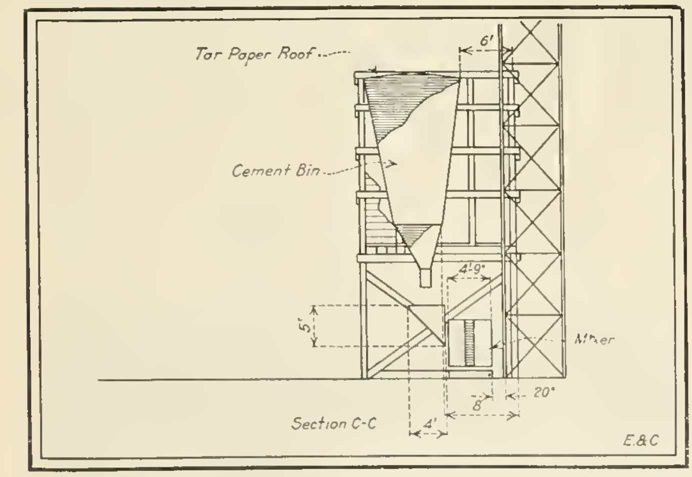
Placing Reinforcing Over Columns.

The sand and gravel bins, as well as the cement bin, when it was used, were loaded with an industrial traveling crane equipped with a 1¼-cu. yd. bucket. This crane came equipped with a 40-ft. boom, but on account of the required height of the bins, it was necessary to lengthen it to a 50-ft. boom, in order to dump into these. Gravel and sand for the concrete were received in bottom dump cars and dumped from a raised track to the storage pit on ground. From this pit the crane took them and loaded to sand and gravel bin as stated above. When possible, the crane took material directly from cars and loaded to bins, but as a rule this was not found satisfactory, as the greater part of material that could be reached by the crane would dump from the cars without shoveling and the process of taking material from the ground was much easier than from cars.



Loading Bins and Their Relation to Mixer.

In order to prevent bucket taking up dirt with the sand and gravel the pits on the ground were planked over. This not only gave insurance of clean materials, but was a considerable help in loading the bucket. Cement was received in box cars and carried by cheap labor to the storehouses shown on the plan and was tranferred to cement bin by traveling crane or directly to mixer hopper by cheap labor, as the case might be. Whenever it was possible, and this was a considerable part of the time, the cement was transferred directly from cars to the mixer hopper by cheap labor. By this method only that portion of a car not used when car was to go on "demurrage" was placed in the store rooms. This, of course, saved one handling charge.



Relative Positions of Bins, Tower and Mixers.

### Reinforcing Steel.

The reinforcing steel was received on cars and unloaded into storage shed furnished by the city. Collapsed spirals, which were used for column bands were furnished by the American Wire Fence Co. Clinton electrically welded fabric was used for slab reinforcing and was made up of M3 and M4 wires, with M8 wire spacers. Round rods were used for column and wall reinforcement and square twisted rods in panels over columns.

The collapsed spirals of larger size were opened up and vertical rods placed and tied before being taken to the building, while the lighter spirals were taken to the floor of building and then assembled. When a considerable number of rods were to be placed in a spiral it was set in place with only a sufficient number of rods to hold it rigid during handling and the balance of rods lowered from a movable platform and tied in place from the outside. Wall steel was placed after one wall form was up, in the usual manner, and tied to this form.

### Structural Steel.

Structural steel consisted of all metal sash, windows, door jambs, column guards doors, etc., and was furnished in pieces easily handled. The work done under this heading was to unload, place and bolt together the members and brace or build into forms.

### Floor Finish.

The floor finish consisted of equal parts of cement, sand and fine crushed rock taken from the ledge and was put on the base before this was thoroughly set. This necessitated several changes of system at the mixer during the day but by a systematic arrangement of the necessary materials the changes were made with hardly a perceptible interruption and the system of pouring top and base practically as one monolithic mass worked out as cheaply, if not cheaper, than the system of pouring for a day or for a day and a half and then topping this out.

A fair day's work with the above concrete plant on slabs was about 300 cu. yd. and on walls and columns was about 200 yd. This varied of course a great deal with conditions. In pouring walls and columns it was found expedient to run concrete with gravity plant to a hopper centrally located with reference to the day's work and distribute from this with carts. On slab pouring, however, the gravity chute was used to pour the concrete directly into place and very good results obtained. The gravity system was also used to spout the floor finish to place.

### Costs.

The actual pouring costs observed on several different occasions including labor only and taking materials from bins by gravity, measuring, mixing and placing were as follows:

| | |
|---|---|
| On slab | 30 ct. per cu. yd. |
| On walls | 39 ct. per cu. yd. |

Scale of wages was as follows:

Foremen, $6; sub foreman, $4; steel men, $2.25; steel men, $3; carpenters, $3; laborers, $2.25; laborers, $2.

Mr. S. A. Jubb was engineer in charge of design and general supervision of the work.

Mr. W. D. Jones was engineer in charge of construction.

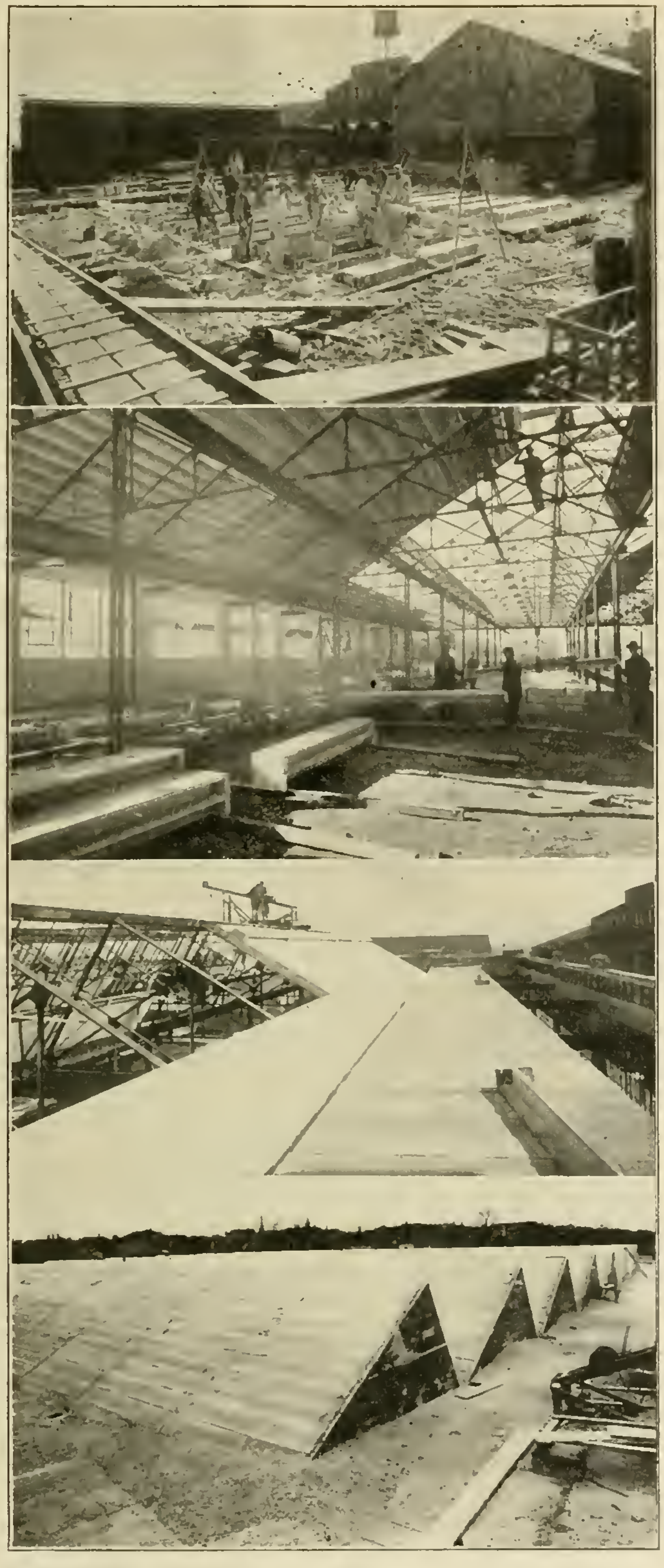
## A NEW TYPE OF ROOF CONSTRUCTION.

As a sequel to numerous tests made at the University of Illinois by Prof. Willis A. Slater, the United States Gypsum Co. has launched the first roof composed of gypsum slabs 10 ft. long, having a clear span of 9 ft. 8 in. This construction has just been used on a steel frame building (approximately 190 ft. x 200 ft. in plan), for the Walker Mfg. Co. at Racine, Wis.

The roof slabs consist of reinforced gypsum beams of T-section, 15 in. wide and 8 in. deep, with a thickness of 1¼ in. for the slab and 2¼ in. for the rib, while the ends are closed by diaphrams 2 in. thick.

Each beam has two ⅜-in. rods in the bottom of the rib, one of these being bent up at the ends as a shear rod and looped to increase the value of bond stress; in the slab is embedded a steel wire mat of No. 14 gage and 4-in. mesh.

These beams were made at the site in wood forms at the rate of about 300 sq. ft. per hour and only required 15 minutes to set (from the time the mould was poured) until the forms were knocked down. The beams were erected in place and walked upon within three hours after being poured, and were designed (upon the same principles as reinforced concrete) to carry a uniformly distributed live-load of 50 lb. per square foot with a safety factor of 4. Tests of five sample beams 24 hours old



Gypsum Slab Roof Construction for 190-ft. × 200-ft. Steel Frame Building at Racine, Wis.

were made with loads of 2,200 and 2,400 lb. or 200 to 218 lb. per square foot with respective deflections of 0.034 and 0.070 in. The total loads were then increased to 3,500 lb., causing slight horizontal shear cracks to appear, but without other signs of failure.

In the roof construction these slabs or beams are carried by light steel trusses for the saw tooth portions and by steel purlins, etc., for the flat portions, all of the supporting steel being spaced 10 ft. c. to c. In general the flat roof portion has a pitch of 1½ in. in 12 in., while the saw tooth construction pitches about 7½ in. in 12 in. The architect for the building was Mr. P. L. Battey, Chief Engineer of B. J. Arnold Co., Consulting Engineers, Chicago. The Arnold Construction Co., also of Chicago, was the contractor.

The weight of these T-beam slabs is about 16 to 17 lb. per square foot. When a flat ceiling effect is desired, instead of a ribbed or beam ceiling, these slabs may be of I section, with the top and bottom flanges similar. These shapes weigh from 22 to 24 lb. per square foot for the same live load. A roof construction of this character is now being erected, the beams weighing 22 lb. per square foot.

For spans approximately 4 to 6 ft. the United States Gypsum Co. supplies factory-made gypsum slabs of biscuit pattern, weighing from 13 to 14 lb. per square ft. and reinforced in the ribs, which are 4½ in. in depth and 1 ft. 6 in. wide, viz., 6 to 9 sq. ft.

At the present time there are over 20 installations of this character being erected, one alone covering a roof area of more than 200,000 sq. ft.

The claims held out by the manufacturers for this new type of roof construction are: Light weight; rapid erection not dependent upon weather conditions or frost; economy in the required quantity of steel; elimination of sweating or condensation troubles; the reflection of light from the white under side; artistic ceiling effects, either ribbed or smooth; low heat transmission, or loss, through the roof (conductivity).

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## CHANGES IN GENERAL SPECIFICATIONS FOR BRIDGE WORK OF ILLNOIS STATE HIGHWAY DEPARTMENT.

The Illinois State Highway Department has issued recently a new edition of its general specifications for all bridge work carried out under the supervision of the department. These specifications (edition of October, 1916) will be used in all bridge work contracted after Jan. 1, 1917, except such work as was advertised previously to Dec. 1, 1916. The new specifications contain a number of important changes, among them being the following:

ROADWAYS.

69. In general, clear widths of roadways for bridges shall be provided as follows:

70. **On Designated State Aid Routes.** Bridges up to and including 10 ft. in length (not less than a proper shoulder to shoulder width of the road).20 to 30 ft.

71. Bridges over 10 ft. and up to and including 60 ft. in length ........................................18 to 24 ft.

72. Bridges over 60 ft. in length........................16 to 20 ft.

73. Length is understood to mean the distance face to face of abutments.

74. No bridge shall, however, when located on a designated state aid route within 25 miles of any city having a population of over 200,000 and on a direct route to such city, have a clear roadway of less than 20 ft., or less than 18 ft. when located within 3 miles of a city having a population between 10,000 and 200,000.

75. **On Principally Traveled Roads.** On principally traveled roads, other than designated state aid routes:

76. Bridges and culverts of 10 ft. or less in length.....20 to 30 ft.

77. Bridges over 10 ft. and up to and including 60 ft. in length ........................................16 to 20 ft.

78. Bridges over 60 ft. in length........................16 to 18 ft.

79. No such bridge or culvert shall, however, when located within three miles by direct route of any city or village having a population of 10,000 or over, have a clear width roadway of less than 18 ft. for bridges having a length of from 10 to 60 ft.

80. **On Secondary Roads.** On lesser traveled or secondary roads:

81. Bridges or culverts of 10 ft. or less in length......18 to 24 ft.

82. Bridges over 10 ft. in length.............................16 ft

83. **Culverts Under Fills.** When culverts are built under fills, the length of the barrel or the culvert shall be such as to permit of side slopes of 1½ horizontal to one vertical, and in addition, a proper top width of fill as follows:

84. On designated state aid routes....................20 to 30 ft.

85. On principally traveled roads....................20 to 30 ft.

86. On secondary roads ...............................18 to 24 ft.

87. It is understood that in case proper provisions for traffic demand, wider roadways may be required.

STONE.

157. Stone used for concreto work shall consist of crushed rock or gravel stones screened to the sizes herein specified, shall consist of clean, sound, hard and durable material and shall have a reasonably uniform gradation between the maximum and minimum sizes hereinafter provided.

No weathered or disintegrated material shall be used.

REINFORCING STEEL.

195. **Type of Reinforcing Steel.** Unless otherwise shown on the drawings, all steel for reinforcement in concrete shall consist of plain square section bars or deformed bars of a type to be approved by the engineer. Round bars may be used in place of the square bars shown on the plans providing an equivalent area of steel is used and on condition that any such substitution be plainly shown on a set of

plans and the same be submitted to the engineer for approval before the steel is ordered.

198. **Material.** Unless otherwise specified, all steel for reinforced concrete shall be mild or medium steel with an elastic limit of not less than 32,000 lb. per square inch. Steel bars shall stand bending cold within a radius equal to twice their diameter through 180 degrees without fracture and shall have a minimum elongation of 22 per cent in 8 in.

### EXPANSION DEVICES.

204. **Rockers.** The rockers shall be made of cast iron of the kind and quality specified in section 309. They shall have a thickness of not less than 2½ in. for spans of 45 ft. or less and a thickness of not less than 3 in. for spans exceeding 45 ft. in length, but in no case shall the unit compressive stress exceed 9,000-401 r lb. per sq. in. All rockers shall have bearing surfaces turned to a uniform radius and smooth surface and shall be provided with two 2-in. holes through the web to facilitate handling.

### STEEL BRIDGES.

223. **Minimum Sizes.** The minimum thickness of metal shall be 5-16 in. except for fillers. Gusset plates shall be not less than ⅜ in. thick. The webs of beams and channels shall be not less than ¼ in. thick.

227. **Lower Laterals.** No permanent lateral bracing need be provided in the plane of the loaded chord, provided a solid concrete floor, reinforced in both directions, is immediately to be placed on the structure. In this case, however, a temporary lateral system consisting of adjustable rods must be used to hold the chords in line while the floor is being placed. After the floor is completed, such temporary laterals must be removed. When permanent lower laterals are used they shall be bolted to the stringers at each intersection.

257. **Pitch of Rivets.** The minimum distance between centers of rivet holes shall not be less than three diameters of the rivet; but the distance shall preferably be not less than 3 in. for ⅞-in. rivets, 2½ in. for ¾-in. rivets, and 2¼ in. for ⅝-in. rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be not more than 6 in. for ⅞-in. rivets, 5 in. for ¾-in. rivets, 4½ in. for ⅝-in. rivets, nor more than 16 times the thickness of the thinnest outside plate. For angles with two gauge lines and rivets staggered, the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than 12 in. apart in either direction shall be used to hold the plates well together. In tension members composed of two angles in contact, a pitch of 12 in. will be allowed for riveting the angles together.

261. **Pitch at Ends.** The pitch of rivets at the ends each way from intermediate panel points of built up compression members shall not exceed four diameters of the rivet, for a length equal to 1½ times the maximum width of the member.

### WORKMANSHIP.

318. **Sub-Punching and Reaming.** Where reaming is required, the diameter of the punch used shall be at least 3/16 in. smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter of not more than 1/16 in. larger than the nominal diameter of the rivet. All reaming shall be done with twist drills in such a manner that the entire circumferences of the holes match perfectly.

328. **Rivets.** Shop rivets shall be driven by pressure tools wherever possible. Field rivets shall be driven by pneumatic tools. Hand driving will not be allowed.

### PAINTING.

353. **Quantity of Pigment.** The mixed paint shall contain not less than 50 nor more than 54 per cent of pigment by weight.

354. Should the paint be in paste form, enough paste shall be added to boiled linseed oil to give not less than 50 nor more than 54 per cent of pigment by weight of the mixed paint.

357. The remaining vehicle will then be extracted four times with 86 degrees naphtha, and the pigment washed once with benzol and twice with ether. When the vehicle cannot be drawn off, the sample will be extracted by centrifuging the paint, and after the vehicle is removed, washing the pigment with naphtha, benzol and ether. One hundred minus the per cent of pigment found will be considered as the per cent of vehicle.

358. **Linseed Oil.** When furnished in paste or dry form the pigment shall be mixed with pure boiled linseed oil. This oil as well as the vehicle obtained from mixed paint will be subjected to standard tests for the purity of the boiled linseed oil. It shall contain no mineral oils, benzine, rosin, rosin oil, maize or corn oil, fish oil, cottonseed oil, rape oil, soya bean oil, or saponified or unsaponified oil other than linseed oil. A small amount of turpentine may be added as a drier only on the approval of the engineer. The film obtained after flowing the oil over glass and allowing it to drain in a vertical position must be dry to the touch after 24 hours at 25° C.

### CREOSOTED TIMBER FLOORS.

373. **Impregnation.** All dimension lumber shall be impregnated with at least 10 lb. and paving blocks with 16 lb. of creosote oil per cubic foot of material. The oil shall be of the kind and quality herein specified for dimension timber and paving blocks.

### CREOSOTED BLOCK FLOORS.

423. **Lag Screws.** Holes for lag screws shall be bored slightly smaller in diameter than the shank of the lag screws and have a depth of 1½ in. less than the length of the screw below the head. The holes shall be bored with a slight inclination from the center of the plank.

### PILING.

463. **Loading.** When used, piles shall be considered as carrying the entire load. They shall ordinarily be spaced not less than 3 ft. nor more than 5 ft. center to center.

465. The maximum load carried by any pile of the minimum dimensions stated in section 461 (at least 8 in. at small end and 10 in. at butt) shall not exceed 10 tons, nor shall the maximum load carried by any pile exceed 15 tons.

### BRICK HAND RAIL.

483. When shown on the plans, brick hand rails shall be constructed in accordance with the following specifications:

484. **Brick.** The brick shall be vitrified, free from unsightly warps, cracks or blisters, and of uniform size. Samples of the brick shall be submitted to the engineer for approval before the order is placed.

485. If brick should be required which costs more than $25 per thousand f. o. b. cars at the nearest available railroad siding, the contractor shall be paid in addition to the sums named in the proposal the excess cost of such brick over and above this amount.

486. **Mortar.** The brick shall be laid in a 1 to 2 Portland cement mortar. The mortar shall be colored as directed by the engineer.

487. **Joints.** All joints shall be raked out to a depth of ⅜ in.

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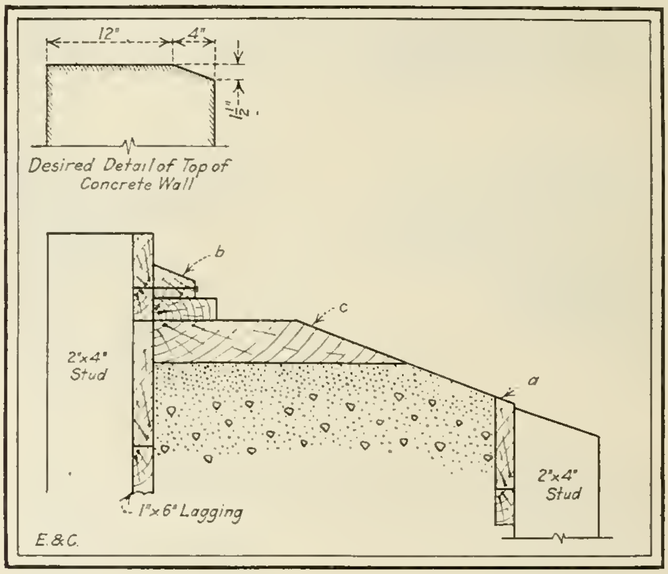
## METHOD OF FORMING BEVELS ON CONCRETE WALLS OR SILLS.

Contributed by Albert M. Wolf.

Where concrete is exposed, it is essential that sharp corners or arrises be avoided by the use of bevels or by rounding them, in order that clipping or breaking off the corners be avoided in removing forms, or in the actual use of the building. Then also, sills, belt courses, or columns are materially benefited in appearance in most cases by beveling or chamfering the corners. Small bevels on top of slabs and belt courses, and on columns can readily be formed by placing triangular strips of the desired size in the forms against which the concrete is placed and formed. The formation of large slopes or bevels (2 to 6 in. wide) on walls and sills, however, is more difficult if the best results are desired and the writer offers the following method as one which will make them possible.



Detail of Special Form for Finishing Bevels on Concrete Walls.

As shown in the accompanying sketch, the inside form can be carried up to any convenient height above the level of the top of the wall, while the top board (a) of the outer form must be beveled at the same slope as desired for the wall and the board carefully leveled and nailed in position. Then nail a strip (b) with top having same bevel at the proper level on the back form. These two beveled boards, (a), (e) and (b), form the guides for the preliminary floating of the mortar finish generally used to finish off the top of walls, but with these alone the wavy line of intersection of the beveled and level portions would not necessarily be dispensed with.

A relatively short piece of plank or board marked (c) in sketch (depending on the depth of bevel) of same width as horizontal surface of the wall and with outer edge cut to level and of proper thickness to slide under the upper guide (b) should therefore be used as an intermediate guide when troweling the beveled portion. By sliding this board along, the horizontal surface will be floated ready for troweling, which should be carefully done along the line of intersection of the surfaces.

This form may seem elaborate to some who have been used to finishing beveled walls in the old hit-or-miss fashion, but on building work, where clean-cut details are required for such concrete work as has largely replaced cut stone, the writer believes the extra expenditure entirely justified from the standpoint of all concerned. It may cost the contractor a few dollars more, but poorly finished exposed concrete surfaces of the kind mentioned, may make the owner and engineer or architect dissatisfied with an otherwise satisfactory piece of work and thus close a promising field of endeavor to the contractor. Most contractors have found that the better class of work pays best and it is to these that this mehod is given, with the hope that it may prove of value.

## FLOORS AND FLOOR CONSTRUCTION IN OFFICE BUILDINGS.*

The types of floor construction most commonly found in the modern buildings are as shown in Figs. 1 to 5, inclusive. These sketches are by no means intended to cover the entire range or even include all of the common types. They show, however, in the opinion of the writer, the more common.

The essential features to be considered in any floor construction are strength, stiffness, durability, fire-proofing qualities, light weight, small depth, and the cost. The construction of high buildings demands that the dead weight and the depth of the floor be reduced to a minimum, consistent with good construction and the cost. In recent years, various new types of floor construction have been placed before the designer and improvements have been made in the older types with the object of accomplishing these results. The forms used for concrete floors are also an important factor and have been subjected to much study and some reduction in the new types.

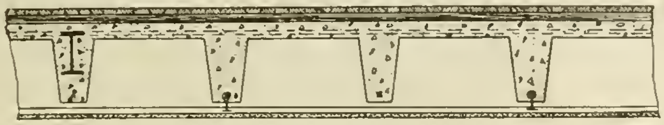


Fig. 1—Concrete Joist Type.

The partitions of office buildings are subject to continual rearrangement to suit different tenants, and the floor, therefore, should be designed to permit a partition to be placed in any position. This requirement is usually satisfied by assuming a certain weight (10 to 25 lbs. per square foot) for partitions and adding this to the dead load of the floor.

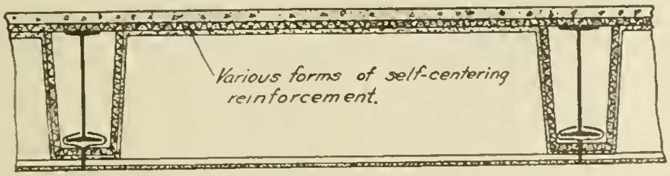


Fig. 3—Concrete Slab on Self-Centering.

Flat ceilings are also desirable and this requires the use of suspended ceilings for some of the types of floor construction. Ample fire protection should be given the beam on both flanges.

This paper does not attempt to discuss the relative advantages, and disadvantages of various types of floor construction. The firms most interested have been quite successful in presenting the respective merits of their particular type and the designer must investigate these claims and make his choice accordingly.

The arrangement and the spacing of the floor beams are influenced by so many conditions, such as location of openings, the locations where comparatively deep beams are permitted, etc., etc., that it is impossible to suggest a particular set of rules to be followed.

The columns having been located and as it is desirable in all cases to transmit the floor loads as directly as possible to the columns, the main panels will be determined from this consideration. The economical span of the type of the floor construction will limit the size of the sub-panels. Thus, for terra cotta arches the usual span is from 5 ft. to 6 ft., for reinforced concrete slabs, the span will probably be larger, but not to exceed 8 ft. to 9 ft., while for the concrete joist construction no intermediate panels will be required, as this construction may safely be used for spans up to 26 ft. or 28 ft.

For large stretches of floor surface the arrangement of the beams may be influenced by the desire to give continuity to the floor construction. Also, usually there will be a number of floor beams in the panel and only one girder, and as the clearance may limit the depth of the girder, it may be desirable to run the beams in the long direction and the girder in the short direction in order that the latter may not become too deep. Another factor which may determine the direction of the girder is the wind bracing, which may require that the deep girders run in the small direction of the building in order to obtain the advantage of the stiffness of the deep girder connections.

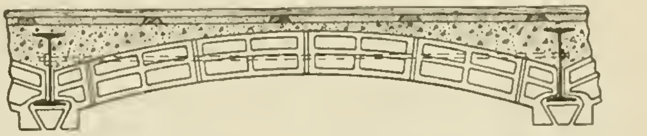


Fig. 3—Segmented Terra Cotta Arch.

In all cases, however, it should be the aim of the designer to make as many panels equal and rectangular as the general plan will permit. This will give duplication in the structural steel, concrete forms, and terra cotta blocks.

Beam to beam connections are made, in most cases, by simple web connections. These may consist of one or two angles, or in skew connections of bent angles or plates. It will be necessary at times to make a connection by resting one beam on top of another, in which case it may be necessary to investigate the webs of these beams for buckling resistance. Beams framing into shallower ones should be avoided, as this requires large cuts in order to clear the flanges of the shallow beam.

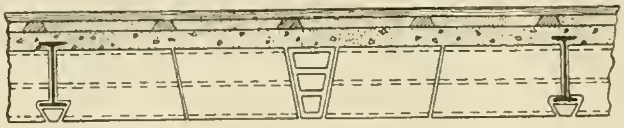


Fig. 4—Flat Tile Arch.

Unnecessary coping and blocking at the ends of the beams should be avoided and this may be done in many cases without injuring the construction in any way. For instance, very often the floor beams are not as deep as the girders into which they frame. By placing the beams at a slightly different elevation than the girder (1 in. to $1\frac{1}{2}$ in.) connection may be made without any cutting. Holes in both the flanges and the web should be avoided where possible and only one size of hole should be used in any one beam. The cutting of beams and the punching of two sizes of holes in a beam, while of small importance in the design of the building, increases the cost of fabrication considerably, and may many times be avoided by a little thoughtfulness in designing.

Beam to column connections are probably most satisfactorily made by using top and seat angles, with stiffener angles if required by the load. This type of connection for the usual sizes of rolled beams is capable of transmitting a larger moment than the web connection and is, therefore, more desirable for wind bracing.

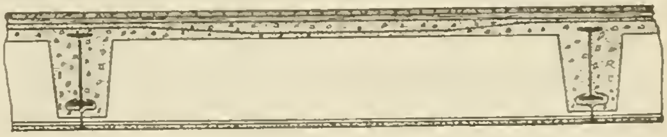


Fig. 5—Reinforced Concrete Slab.

In many cases the clearance lines will not permit the use of stiffener angles. In such cases simple web connections must be used. A satisfactory wind bracing connection may very often be made by the use of web connection angles with top and bottom seat angles.

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*From a paper, "Comparative Designs of Office Buildings," presented before the Western Society of Engineers by Fred Ruchts and printed in the October journal of the society.

When a shallow beam frames into a deep beam, this should be carried on a shelf angle and a side connection angle instead of the usual web connection. This connection is an advance to the erector, as the shelf angle acts as an erection seat, thus facilitating the erection. This is especially noticeable when two small beams frame opposite each other. The smaller beams thus become plain punched beams without riveted connection angles and take a lower classification and a less unit cost.

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## SLAB DEFLECTION AND SUBSIDENCE OF COLUMN SUPPORTS.*

The structural utility of continuous panels is so great as to outweigh their risks and practically to necessitate their adoption. The fact that the applied moments and resisting moments in slabs are unequal does not, however, prevent us from applying the theory of flexure to slabs as well as to beams, although it does prevent us from calculating the moment of inertia of the resisting materials in slabs in the same manner as in beams. But those deductions from the theory of flexure which are independent of the magnitude of the moment inertia are valid equally for beams and for slabs. Such, for example, are the relative deflections and vertical displacements of different points in the span. This it is which has made it possible to treat with success an important question which arose in the discussion of the test of the floor of International Hall.

In this floor slab the foundations of the columns proved sufficient to carry the test loads without yielding by amounts large enough to have considerable effects upon the stresses and deflections of the four loaded panels, each of which was 18 by 18 ft. square. The floor as tested was a deck slab with no columns on its upper side. It was three panels wide and nine panels long, and was built into the surrounding walls of an old brick building by cutting into them somewhat for space to place steel and pour concrete, so that the edges of the slab were made integral so far as possible with the walls. The four panels which were tested formed a square near the middle of one side of the slab, two of them being in one tier of wall panels and the other two in the middle tier adjacent to them. In this floor, with its two rows of supporting columns parallel to the long sides of the building, certain vertical displacements were measured at the columns and at mid-span between columns and walls, both before and a week after the removal of the final test load, and the question was to determine whether the recovery was as much as 80 per cent. of the maximum deflection, and so whether there still remained as much as 20 per cent. of the maximum. The solution of this problem implicitly requires the determination of the magnitude of the vertical displacements which would occur in the slab by reason of the subsidences of the column supports only; for the actual vertical displacement at any point of the slab is the sum of two kinds of displacement; first, that due to the bending by reason of subsidence of the points of support, and, second, that due to bending by reason of the applied load. The fact that the subsidence of columns was itself also due to the applied load is immaterial, since the effect would be the same were the subsidence due to some other cause.

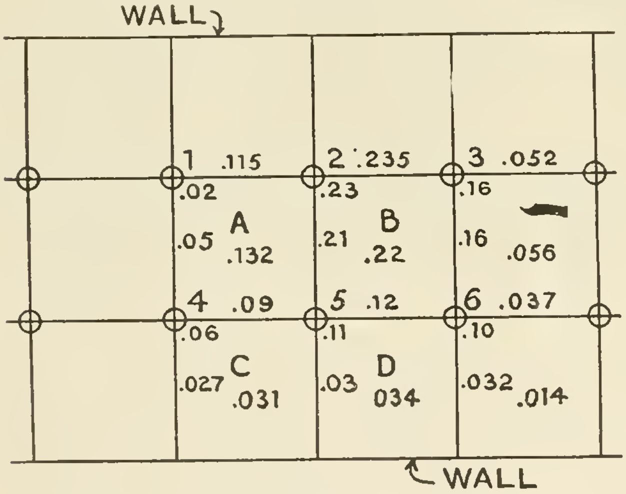

Fig. 1.

When that part of the vertical displacement at any point which is due to the subsidence of supports is subtracted from the actual vertical displacement observed at that point, the remainder is the true deflection and may be either that due to the effect of the load in bending the slab or to the residual bending effect after removing the load, according as the load is still resting upon the slab or has been removed. The ratio of the remainder after removal to the remainder before removal will show how much the recovery falls short of being complete.

Let these four panels be designated by A, B, C. D, respectively, as shown in Fig. 1, with columns numbered from 1 to 6. Panel B is the centre of the entire floor. Let the reinforced direct belts extending across the slab over the columns be regarded as continuous beams fixed horizontally at the walls. The assumption that they are fixed at the walls is probably not entirely correct, but more nearly so than the assumption of mere support at the walls. It is found that the latter assumption gives results which do not differ much from those obtained by assuming the ends to be fixed in direction as well as position. If L be taken as the distance between successive columns, these belts or beam strips, which may be taken roughly as having a width of 0.5 L, are not of uniform moment of inertia throughout their lengths, but will, for the purpose of preliminary investigation, be assumed as uniform, and their irregularity of cross-section will be allowed for later.

Given a uniform continuous beam of three equal spans, each of length L, as shown in Fig. 2, whose extremities are fixed horizontally on the same level, but whose intermediate points of support at points 1 and 2 are depressed by the observed subsidence $z_1$ and $z_2$, respectively, below the level of the extremities, to find the displacements $z_{12}$, $z_{01}$, $z_{23}$, at the middle of the centre and end spans respectively, there being no stress or displacements due to any other cause than the subsidences $z_1$ and $z_2$.

Let $M_0$ and $M_3$ be the moments at the extremities and $M_1$ and $M_2$ at the intermediate supports, respectively.

Then, by making use of the theorem of three moments, which applies in its general form to any two successive spans of a straight beam with supports at any arbitrary levels, we have the following form equations by taking from successive pairs of spans: The first pair, Equation (1), consists of a span of zero length and a span extending from the wall at 0 to the first row of columns at 1. The effect of a span of zero length is to give the slab a fixed horizontal direction at the wall. The second pair of spans, Equation (2), extends from the wall at 0 to the first row of columns and from the first to the second row of columns at 2. The third pair, Equation (3) extends from the first row of columns at 1, across the second row to the other wall at 3, and the fourth pair, Equation (4), from the second row of columns at 2, to the second wall at 3, and includes a span of zero length at that wall.

The notation may be understood from a diagram in which the tangents at the 0 and 3 are fixed in a horizontal position and the vertical displacements or subsidences at the intermediate supports 1 and 2 are of known amounts, $z_1$ and $z_2$, and the vertical displacements at mid-span are designated by $z_{01}$, $z_{12}$, and $z_{23}$, respectively, while the applied bending moments are denoted by the letter M with corresponding subscripts, and the length of the equal spans between supports by L.

$$6\ EIz_1 = (2M_0+M_1)L^2 \quad \ldots\ldots (1)$$
$$-6\ EI(2z_1-z_2)=(M_0+4M_1+M_2)L^2 \quad \ldots\ldots (2)$$
$$6\ EI(z_1-2z_2) = (M_1+4M_2+M_3)L^2 \quad \ldots\ldots (3)$$
$$6\ EIz_2 = (M_2+2M_3)L^2 \quad \ldots\ldots (4)$$

Considering now the mid-displacements $z_{12}$ of the middle span 12, it may be expressed in terms of the two end moments and end displacements of that span as follows:

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*From a paper by Prof. Henry T. Eddy, University of Minnesota, in the December Journal of the Franklin Institute.

$$6\,EI(z_1+z_2-2z_{12}) = \tfrac{3}{4}(M_1+M_2)L^2 \quad \ldots\ldots (5)$$

as appears from the fundamental equation of moments and shears used in establishing the equation of three moments.

The solution of these five simultaneous linear equations by the method of indeterminate multipliers or otherwise gives as a result

$$z_{12}=\tfrac{5}{8}(z_1+z_2) \quad \ldots\ldots (6)$$

A similar consideration of the mid-displacement of the end span 23 shows that

$$6\,EIz_{23}=\tfrac{1}{8}(M_2+5M_3)L^2 \quad \ldots\ldots (7)$$

The solution of the first four simultaneous linear equations and (7) gives

$$z_{23} = (19z_2-4z_1)/40 \quad \ldots\ldots (8)$$

and by symmetry

$$z_{01}=(19z_1-4z_2)/40 \quad \ldots\ldots (9)$$

Hence

$$z_{01}+z_{12}+z_{23} = z_1+z_2 \quad \ldots\ldots (10)$$

which is a fundamental equation of displacements in this case of no loads.

In case the assumption were that the walls are simple supports and exert no restraint, the values of the displacements at mid-span have been found to be

$$\left.\begin{array}{l} z_{12}=23(z_1+z_2)/40 \\ z_{23}=(29z_2-6z_1)/40 \\ z_{01}=(29z_1-6z_2)/40 \end{array}\right\} \quad \ldots\ldots (11)$$

from which it appears that this would make the displacement of the middle span a little less and at mid-span of the end space a little greater than when the ends are fixed, and the same kind of effect, but of smaller amount, will be produced by any relaxation of fixity at the walls.

It will be noticed that from (11) that

$$z_{12}=z_{01}+z_{23}$$

It is evident that the floor under consideration may be taken to consist of beam strips not only crosswise from side wall to side wall, as has just been done, but also as made up of beam strips parallel to the side walls and extending lengthwise of the building, and that the agreement of the results of computations by these two methods will tend to establish their correctness. Suppose the beam strips to each have a width of ½L extending over the two rows of columns parallel to the long side walls, with a strip of the same width lying between these two. If the length of these strips be taken as 4L, they may be assumed to have their ends practically fixed horizontally, with certain observed vertical displacements at the three intervening columns. The problem in this case is this: Given the vertical displacements $z_1$, $z_2$, and $z_3$ at points of support 1, 2 and 3 of a beam fixed horizontally at the ends 0 and 4, to find the vertical displacements $z_{01}$, $z_{12}$, $z_{23}$, and $z_{34}$, at mid-span between each pair of supports. The equations are like those already used in the case of three spans, and the values arrived at in the same manner are:

$$\left.\begin{array}{l} z_{01}=(106z_1-21z_2+6z_3)/224 \\ z_{12}=(142z_1+133z_2-30z_3)/224 \\ z_{23}=(142z_3+133z_2-30z_1)/224 \\ z_{34}=(106z_3-21z_2+6z_1)/224 \end{array}\right\} \quad \ldots\ldots (12)$$

It will be noticed that in this case

$$z_{01}+z_{12}+z_{23}+z_{34}=z_1+z_2+z_3 \quad \ldots\ldots (13)$$

which is an equation of deflections for four spans similar to (10) for three spans.

On Fig. 1 which shows a plan of the panels of the test, are inscribed, at columns 1 to 6, the amounts of the vertical displacements observed under the final load in inches, and at mid-span between these columns the vertical displacements, computed according to the foregoing equations, that would take place in a uniform slab by reason of the displacements at the columns without applying any load to the slab except the reactions at the columns which are necessary to produce the displacements at the columns.

Displacements at panel centres are also given. These last are computed both by taking beam strips crosswise and lengthwise of the floor midway between the beam strips already computed across the tops of the columns. Practically the same values at panel centres are obtained from the computation by strips crosswise as lengthwise. This affords a satisfactory check on the work. Were the slab of uniform moment of inertia throughout, the displacements which have been computed at mid-spans and panel centres would express the position of the surface from which true deflections should be measured, or the surface of zero deflection from which deflections due to the load or lack of recovery are to be measured. That however, is not entirely correct for a floor slab, by reason of the great relative stiffness and extent of the column heads, which must be allowed for. The side belts are weaker near mid-span than elsewhere. The kind of effect that this produces may be made evident by considering what would be the effect of joints at mid-span of the beam strips across the floor. That would cause angles in the strips at each mid-span with comparatively straight portions over the columns. At mid-span in the centre of the strip the displacement would evidently be increased by such joints or by any weakness of this kind. In the case of the test under consideration it is estimated that the combination of a central conduit in each panel tier parallel to the long side walls, with the lack of columns intergal with the slab above it, added not less than 25 per cent. to the computed vertical displacements at the centres of panels A and B and midway between those points, these being the points of maximum deflection at which the percentage of recovery is to be determined.

Table 1 gives in column 1 the computed vertical displacements at these points, and in column 2 these amounts increased by 25 per cent., to take account of the increased displacement by reason of lack of uniformity in the slab. Column 3 gives the observed displacements under the maximum load, and column 4 the observed displacement after removal of the load and recovery. Column 5 is the difference between column 3 and column 2, or the deflection under the load. Column 6 is the difference between column 4 and column 2, or the deflection after removal of load and recovery. Column 7 is the ratio of column 6 to column 5, or the percentage which with the residual deflection is of the maximum. Column 8 is 100 per cent. less the per cent. in column 7, or the percentage of recovery which has a mean value of 80.7.

TABLE I.—VERTICAL DISPLACEMENTS AND DEFLECTIONS IN INCHES.

| At center of | 1<br>Computed for uniform slab. | 2<br>Increased 25 per cent not uniform. | 3<br>Maximum observed displacement. | 4<br>Minimum observed displacement. | 5<br>Maximum deflection column 3 less column 2. | 6<br>Minimum deflection column 4 less column 2. | 7<br>Percentage of residual deflection. | 8<br>Percentage of recovery. |
|---|---|---|---|---|---|---|---|---|
| Panel A ...... | 0.12 | 0.16 | 1.04 | 0.38 | 0.88 | 0.22 | 25 | 75 |
| Span 2—5 ..... | .21 | .25 | .95 | .37 | .70 | .12 | 17 | 85 |
| Panel B .... . | .22 | .264 | .98 | .38 | .716 | .116 | 16 | 84 |
| Mean ....... | 0.19 | 0.225 | 0.99 | 0.38 | 0.765 | 0.152 | 19.3 | 80.7 |

The application of a rule requiring a recovery of 80 per cent. in this case, however, discriminates against the floor structure and attempts to have it make good the shortcomings of the faulty foundations on which the columns rest. At the time of the maximum load, when subsidence of the columns took place, the columns were subjected to a very considerable bending moment by reason of the tipping of the floor, which was integral with the column heads. This caused the foundation of each column not only to sink vertically, but to tilt at the same time in an inelastic displacement. On removal of the load, any restoration of the foundation either to its original vertical position or level would have to be accomplished, not by any elastic effort of the foundation itself, but by an elastic effort coming from the floor itself. Not only was work required to displace the foundation at first, but additional work will be required after the removal of the load to right the foundation, or else the foundation will itself tend to restrain the slab and hold it in its displaced position not merely by reason of its vertical displacement, but by reason of its tilted position in addition to that. Thus it is that the displaced foundations tend to prevent the recovery of the slab in other ways than merely by the vertical displacements which have been considered in the preceding computations.

## PROTECTION OF STEEL WORK FROM LOCOMOTIVE BLASTS.

A fireproof sheathing, composed of asbestos fibre and cement, has given excellent results in protecting the steel work of the Whitehall St. viaduct at Atlanta, Ga., from the effects of smoke, steam and cinders from locomotives. The asbestos sheathing is $\frac{3}{8}$ in. thick and is supported by frames attached to the girders and beams by adjustable hangers, bolts, etc. This forms one continuous rigid hood over the center lines of the tracks under the bridge. The actual cost of this protection was $4.45 per lin. ft. of track, or $1.23 per sq. ft. of protected area.

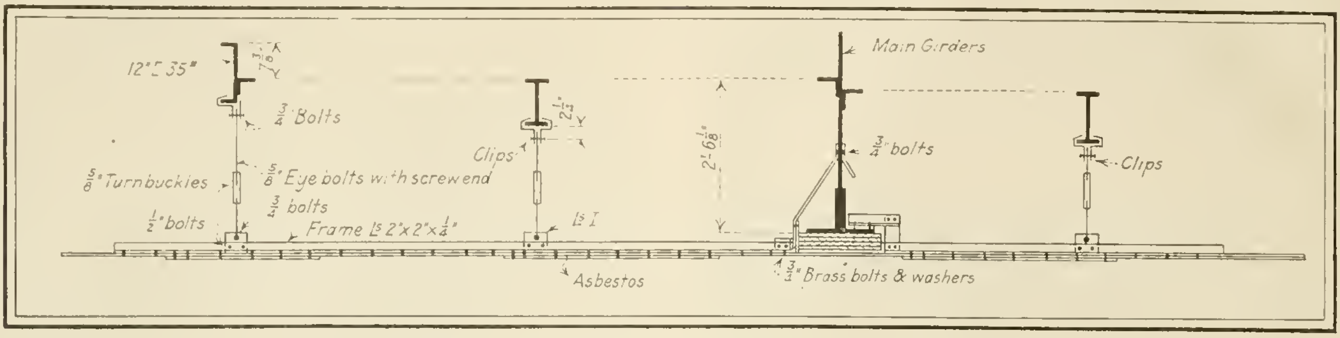
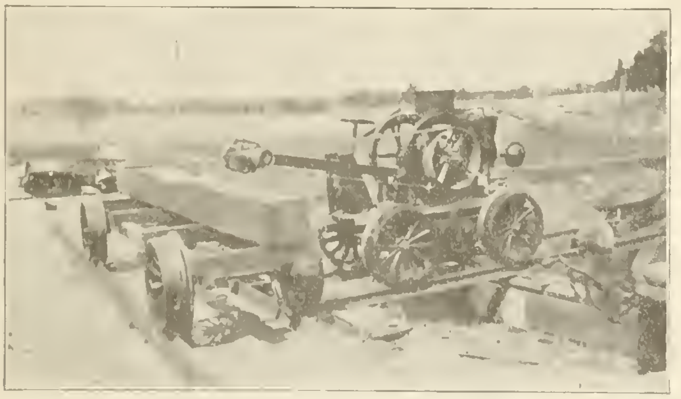


Diagram of Frame, Suspenders and Asbestos Sheathing.

An examination of the protection after 15 months' service showed that the sheathing had not suffered from the locomotive blasts and apparently the sections of the asbestos sheets were not reduced in thickness. The protection was designed by C. E. Kauffman, Engineer of Bridges and Estimates, City of Atlanta.

## PORTABLE ENGINE DRIVEN FRAMING MACHINE.

A framing machine that is claimed to do more and better work than six mechanics can do with hand tools is illustrated below. This machine consists of a small car, 38-in. wheel base, 2-ft. gage, 20-in. wheels, on which is mounted a 4 H. P. gasoline engine. In front of this engine is hinged a cast steel arm, 4 ft. long, supporting a 10-in. grooving head. This arm can be adjusted up or down by a screw passing through its center and bearing on a steel plate near the front of the car. Attached to this plate are two wing plates, one on each side of the cutter arm, which serve as a support to the arm. By the use of a bolt passing through slotted holes in these plates the arm may be clamped in any desired position. A $1\frac{1}{2}$-in. mandrel supports the cutter head at one side of the outer end of the arm; on the other side is attached a pulley which is belted to the engine. The illustration also shows the material car which has 10 ft. wheel base and 2 ft. guage. The ties, two at a time, are loaded on this car which is placed at right angles to the machine car. The timber is scribed across to give location of daps, and the work proceeds as follows: By operating a lever shown clamped to the front wheel of the small car the whole machine is pushed forward or backward, the arm passing over the work in a horizontal line and at such depth as may be desired to produce the proper size or thickness of the tie or timber. A 2-in. cut is made with each movement back and forward. Thus by pushing the lever forward and then drawing it back, a clean, square, smooth cut 4 in. wide is made across two ties. About three such movements complete an ordinary dap in a tie and two for a guard rail dap. One man is needed to push the car along 2 in. at a time as the cuts are made.



Portable Engine-Driven Framing Machine.

A saw is furnished with the machine. It is interchangeable with the cutter head on the same arbor, thus making a convenient rig for sawing form lumber, building stock, splitting wedges, etc.

The machine described above is manufactured by J. E. Toohey, Grand Rapids, Mich.

## PERSONALS.

C. C. Huffine has been appointed City Engineer of Frankfort, Ind.

W. J. Parker has been appointed County Highway Engineer of Jefferson County, Arkansas.

At a meeting of the Board of Directors of J. G. White & Company, Incorporated, New York, R. B. Marchant, Treasurer of the Corporation, was elected to the office of Vice President.

W. D. Salter has been appointed city engineer of Boulder, Colo., succeeding George R. Joslin, resigned. Mr. Salter for the past 10 years has been Assistant Engineer for the city of Denver, Colo.

A meeting of the civil engineers of Florida was held at Jacksonville, Fla., on Dec. 22 and 23 to organize the Florida State Engineering Society. L. D. Smoot, Commissioner of Public Works of Jacksonville, was in charge of arrangements.

W. L. Clark, heretofore Assistant Highway Engineer of the State Highway Department of California, has been appointed Division Engineer to succeed A. E. Loder, who resigned to become Assistant Chief Engineer of the U. S. Office of Public Lands.

J. K. Choate, Vice-President of the J. G. White Management Corporation, has just returned from a six weeks' trip to Nicaragua, where he spent considerable time inspecting the property of the Ferrocarril del Pacifico de Nicaragua, which is being operated by the J. G. White Management Corporation.

## OBITUARY.

Frederic H. Reed, vice-president of J. G. White & Co., Inc., died Dec. 9, aged 51 years.

Charles H. Hersey, president of the Hersey Manufacturing Co., Boston, Mass., died Dec. 9 at his home in Roxbury, a suburb of Boston, aged 86 years.

Charles Wiley, vice president and treasurer of John Wiley & Sons, publishers of scientific work, New York City, died Dec. 3 at his home in East Orange, N. J., after an illness from heart trouble of four months' duration. He was 82 years old.

T. E. Calvert, chief engineer of the Chicago, Burlington & Quincy R. R., died Dec. 19 at his home near Lincoln, Neb., after an illness of about 6 weeks. Mr. Calvert entered the employ of the Chicago, Burlington & Quincy R. R. in 1871, as an axman. He became assistant engineer and in 1878 was made chief engineer of the lines west of the Missouri River. In 1884 he was appointed General Superintendent of the Western lines, and 20 years later he became chief engineer of the Burlington system.

## INDUSTRIAL NOTES.

The Novo Engine Co., Lansing, Mich., will give its employes a wage dividend. All employes who have been continuously in the employ of the company for the year 1916 will receive an amount equal to 5 per cent on their total wages earned during the twelve months previous to Dec. 31st, 1916, at their regular rate per day. To those who have been in the employ continuously for six months, but less than twelve months, an amount will be paid equal to $2\frac{1}{2}$ per cent. This is the second annual wage dividend of the company.

A motor car factory running full blast and 6,000 persons present at a reception and luncheon was the unusual feature of a factory housewarming which began at 8:30 a. m. December 16 and ended in a dance at night in a new manufacturing building of The White Motor Company in Cleveland. The dance was one of the largest ever held in this country, over 8,000 persons attending. Special transportation facilities were provided by the street railway company to handle the crowd.

Among the contracts recently awarded the Raymond Concrete Pile Co. of New York and Chicago, are the following: Reconstruction of old ore unloading dock and 600 ft. of additional new ore unloading dock for the Marine Department of the Bethlehem Steel Co. at Sparrows Point, Md. Also foundations of Raymond piles for their new blacksmith shop. Concrete piles in the foundation of a new building for the Swift Packing Co., Kansas City, Kan. Concrete piling in the foundation of the Campbell Apartment, Chicago, Ill. More concrete piling under buildings for the Sizer Forge Co., Buffalo, N. Y. Raymond piles in the foundation of the boiler house for the Revere Sugar Co., Boston, Mass. Piling foundation for the Cadillac Motor Co. at Detroit, Mich. Raymond concrete piles for the foundation of the Goodyear Tire & Rubber Co. building at Akron, O. Concrete piles for the Holy Trinity Church, Newark, N. J.

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